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UNIVERSITY OF ALBERTA

THE VALUE OF WATER RIGHTS IN SOUTHERN ALBERTA: A HEDONIC PRICE MODEL APPROACH

BY

SEAN AURELL ROYER ©

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
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IN

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Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled *The Value of Water Rights in Southern Alberta: A Hedonic Price Model Approach* submitted by Sean Aurell Royer in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics.

T. S. Veeman
Dr. Terry S. Veeman

Dr. Wiktor L. Adamowicz

Michele Veeman
Dr. Michelle M. Veeman

J. A. Robertson
Dr. James A. Robertson

Dedicated to my parents, LaVerne and Aurell, for their love and support, my wife Kirsten for her patience and understanding and to Marion for her unconditional love.

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ABSTRACT

The purpose of this research is to determine the value of water rights in Alberta. This information will help policy makers and farmers gain a better understanding of the potential value of water as an input into agricultural production and as an environmental good. This information is also key in aiding policy makers to determine the economic merits, shortcomings and problems associated with instituting a system of transferable water rights in Alberta.

A hedonic price model similar to that used in Xu, Mittlehammer and Barkley (1993), Coelli et al. (1991) and other land based studies, is developed and applied to determine the implicit value that farmers place on having access to irrigation water in southern Alberta. This value may provide us with an indication of the value of water rights in this region. The hedonic approach to market analysis uses the relationship between the price of the land and the attributes of the land, such as water availability, soil quality and other attributes, to explain differences in land prices.

The focus of this study is an area located in the south eastern portion of the province of Alberta encompassing the counties of Wheatland, Newell, Cypress, Forty Mile, Taber, Warner, Lethbridge and Vulcan and the irrigation districts of Western, Eastern, St.Mary's, Taber, Lethbridge Northern, and portions of Raymond. Information was collected on the economic and physical characteristics of 230 land parcels sold in 1993 and early 1994 in this study area.

The results indicate that the overall implicit value of water rights in the study area is $190 per acre. It was expected that this value would vary substantially between different sub-markets within our study area. This expectation was based on traditional assumption that demand for irrigation water is higher in regions where there is a greater proportion of specialty crops grown since these crops are considered a higher valued use of water. However, further testing revealed that this was not the case. High beef prices combined with low prices of most specialty crops at the time of the observations, may have caused demand to shift away from traditionally higher valued uses of irrigation water to lower value uses such as pasture irrigation.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Alberta is considering revising its existing system of water rights in favour of a system where water rights are transferable. The proposed system is thought to be more efficient in the utilization and conservation of water resources. Before any system of transferable water rights can be instituted, it is important to evaluate its potential merits and shortcomings. An important part of this evaluation requires that we gain a better understanding of the value of water rights in Alberta. The purpose of this study is to provide this information.

Xu, Mittlehammer and Barkley (1993), Coelli et al(1991), Lloyd-Smith (1987) and many others have recently used the hedonic price model to measure the implicit value of different environmental goods in rural land markets. In this study, the hedonic approach will be used in a similar manner to determine the implicit value that farmers place on having access to irrigation water. This value can give us an indication of the anticipated prices which may prevail in a transferable water rights market in southern Alberta.

1.2 Current System of Water Rights in Alberta

Alberta currently administers water use according to a system of administrative apportionment (Percy 1977, Veeman, 1985). This system evolved from a riparian rights system originally imported from Great Britain (Freeman and Veeman, 1993). Riparian rights allowed land owners to extract and use any water adjacent to their land as long as it did not interfere with the use of any down stream users. This system was developed in

England and applied in parts of eastern North America, but it proved inappropriate for the more arid conditions which characterised parts of Alberta. In response to the inadequacies of the riparian system, the North West Irrigation Act (1894) was instituted (Freeman and Veeman 1993). This act was influenced by similar acts passed in Australia and the U.S. Under the new act, ownership of the water rights were vested with the crown and water was allocated according to when a person or company began using the water. These principles were later incorporated into the Water Resources Act (1931) which underlies the current system of administrative apportionment (Freeman and Veeman 1993). Under the system of administrative apportionment, ownership of the water is vested with the crown. Land owners can use the water, for other than domestic purposes, only if they obtain a license from the government to do so (National Economics Research Associates Inc., 1992). The procedure to obtain a license for consumptive use includes making a formal request to the government outlining the proposed use. The permits are granted for indefinite periods of time and can only be revoked for very specific reasons such as if the user "abandons or ceases to use or wastes any water..." (Gisvold, 1956); breaks regulations; or, does not abide by the conditions of the license. The permits have a temporal priority based on "first in time, first in right." That is, those who are first to acquire a water permit have the most senior rights and their use takes precedence over the rights of more junior users (those who acquired water permits later). During times of scarcity, the permits of the senior right holders may be filled in full before those of others are met.

Although Alberta's system of permits is based on seniority, in practice much of the water is allocated proportionally. Eighty five percent of the water rights in southern Alberta are held by the irrigation districts. The permits held by the districts are based on seniority, but water allocations within each district are usually proportional. In times of shortage, Alberta Environment has often been successful in convincing permit holders to share limited supplies (Alberta Environment, 1991 and Birch 1992); however, if the senior holders refused to cooperate, there is no legal means of coercing them to share their water allotments (MacLock, 1992).

Water permits can be transferred freely along with the land to which they are attached but only if the water continues to be used on that land for the originally specified purpose. Permits cannot be transferred to another use or to another location without prior approval and changes in use of the water are only permitted if the new use has higher priority than the original use (e.g. water permits for agricultural use can be transferred to municipal use, which ranks higher on the priority list, but not to industrial use, which has lower priority). Very few, if any, changes in use have ever been proposed (Birch, 1992).[1] Separating the water permit from the land it is attached to is even more difficult since this requires intervention from the provincial cabinet.

1.3 Reform of Alberta's System

The existing distribution of water permits in Alberta reflects the sequence in which various individuals and enterprises filed claims to use water. However, the value of water in different uses and locations is likely to change over time. Crops that were valuable in the past may now be worth less, so the marginal value of water used to irrigate these crops could be substantially less than before. Conversely, the relative value of other crops may have risen, making water a more value input into their production (National Economic Research Associates, Inc., 1992). Other factors such as increased salinity or water logging may have also influenced the value that users place on water. Despite these changes, the allocation of water has remained the same. Users who that were first to acquire water permits still have the premier rights to it. This posed few problems as long as supply of water exceeded demand for permits. Now, however, some basins have been fully allocated so that new and existing users cannot obtain water permits even if the value of water to them would be very high. At the same time, other existing permit holders may place relatively low value on some of the water they use. These permit holders may have little incentive to conserve water even if it is relatively inexpensive to do so. The result is that water is not used efficiently since some of it is locked into low valued uses by the nature of Alberta's water laws.

---

[1] It is not clear exactly what constitutes a change in use. For instance, a change in crop might be considered a change in use if the water requirements of the new crop are significantly different from the old one (MacLock, 1992)

The Alberta government has recognized that Alberta's existing system of water rights fails to promote more efficient use of water. Changes to this system are likely to include provisions for the transfer of water rights. If water rights are transferable this will aid in the development of a "market" for the transfer of rights. Market forces will then increase the value of a previously undervalued resource by pricing water rights according to demand and supply in each trading area. This price will vary significantly depending on the relative scarcity of water in different areas. Transferable water rights will promote efficient use of water by providing users with an economic incentive to conserve water and to consider reallocating it to higher valued uses. The proposed system may become increasingly important as pressures on existing supplies of water increase and the current system becomes unable to deal with the potential conflicts.

1.4 Problem Specification

An economic analysis of the benefits that can be gained by introducing transferable water rights must ultimately rest on the estimates of the economic value of water rights in alternative uses. Estimating these benefits poses a methological difficulty because there currently is no information on the value of water rights in a market setting. Hence, it is important to seek other sources of information on the value of water rights to farmers. Ideally, this would involve information relating directly to farmer willingness to pay for water.

Rural land prices can be used to derive an estimate of the market value of water rights. Traditional economic theory implies that the equilibrium price for a parcel of land will represent the value of a stream of rents produced by the land. In agriculture, the productivity of land can differ greatly across a number of different sites. These productivity differentials will yield differences in the rent for land and therefore different land values (Freeman, 1993). Therefore, if the presence of irrigation makes a parcel of land more productive, this productivity difference may be reflected in the land rent or land values. The hedonic technique can be used in this study to separate the effects of water rights on the land value and to extract the implicit marginal value of water rights from the price of the land.

1.5 Objectives of the Study

The general objective of this research is to help improve the economic information base from which to evaluate a proposed system of transferable water rights. The more specific objectives of this study are:

(1) To gather information on recent sales for both irrigated and adjacent dry land parcels in southern Alberta along with any pertinent information on the physical characteristics of these land parcels.

(2) To construct a hedonic price model to isolate the implicit marginal value of water rights attributable to the land.

(3) To estimate the implicit value of water rights in southern Alberta.

1.6 Organization of Study

This study consists of six chapters as well as appendices and references. In Chapter Two, a theoretical review of the hedonic price model and some of the key assumptions underlying this technique are presented. A number of weaknesses which are inherent in the this model are also discussed. In Chapter Three a review of previous studies that have applied the hedonic price model in the rural land market is provided. Chapter Four includes a discussion of the methods used to gather the data and to specify the model used in this application. In Chapter Five a summary of the empirical results of the model specified in Chapter Four is provided. A number of econometric issues such as multicollinearity, heteroscedasticity and functional form are also discussed in this section. Finally, in Chapter Six, a summary of the findings and limitations of the study are provided along with suggestions for further research.

CHAPTER 2

HEDONIC PRICE THEORY: THEORETICAL CONSIDERATIONS

2.1 Introduction

Economists have been documenting the relationship between prices of consumer goods and the properties of these goods for some time.[2] The latter half of the 1970's and the decade of the 1980's saw an explosion of studies using hedonic price theory to determine the monetary values of non-market amenities and dis-amentites. It has become more accepted that price differentials among consumer goods may reflect differences in the quantities of various characteristics of these goods and that these differences have significance for applied welfare analysis. This chapter is concerned with hedonic theory and the general problems researchers encounter when using this technique to estimate the values of characteristics or attributes associated with goods.

2.2 The Model

The hedonic approach to market analysis uses the relationship between the price of goods and the characteristics of goods to explain differences in the prices of goods. In the land market, hedonic pricing may be used to analyse the relationship between the price of the land and the attributes of land such as soil quality, climate, access to irrigation water and so forth to help explain why some parcels of farm land have a higher value than others. Different land plots within a given region will have a variety of different landscapes and soil types. An important assumption of the hedonic technique is that these regions are treated as a single land market (Freeman, 1993). It is also assumed that individuals have perfect information on all the alternative types of land available and that they are free to choose any land plot within the market for production (Freeman, 1993). It is as if the land market were one huge market offering a wide variety of land characteristics. Of course, individuals cannot mix and choose characteristics from different land plots; instead, consumers must choose land plots that have a fixed amount of land characteristics which they desire the most. Therefore, the object of this theory is to describe how prices of various highly differentiated land plots would be determined under conditions of perfect competition.

---

[2] Early contributions to the development of Hedonic Theory were made by Lancaster (1966), Gorman (1956) and Griliches (1971). However, the concept can be traced back at least as far as Court (1939).

If we assume that the land market is in equilibrium, that is , all land owners have made their utility-maximizing choices of land parcels given the prices of alternative land plots and their characteristics, then the price of the i-th quarter section of land can be described as a function of a number of physical, climatic and environmental characteristics of the land. This relationship can be represented by the hedonic equation (Rosen, 1974):

$$P_i = P(Z_i) + u_i \qquad i = 1,\ldots,n \tag{2.1}$$

where P_i is the purchase price of the parcel, $(Z_1,\ldots,Z_N)$ is a vector of the n characteristics of the farmland and u_r is a random disturbance term.

This relationship between price and an attribute such as water would be linear if the amount of water rights attached to the land could be separated from it and varied independently (Crouter, 1987)[3]. However, this is often not possible; therefore, it is possible to have nonlinear forms of the hedonic price functions as well.

The equilibrium price schedule is defined by the interaction of the bid curves and the offer curves. That is , the hedonic price function is determined by the interaction of the consumers and suppliers of characteristics. Obviously, producers would like the lowest possible price for each characteristic of the land they are purchasing. On the other hand, sellers of the land would like to receive the highest possible price they can for a certain characteristic of the land. These conflicting goals are reconciled in the market when buyers are matched with purchasers such that buyers cannot increase their satisfaction from buying this characteristic from someone else and sellers of the characteristic cannot increase their satisfaction by selling to someone else. Graphically, this relationship is represented by Rosen's well known diagram in which the bid and offer functions are just tangent to one another in Figure 2.1 (A) (Anderson and Bishop 1986).

In Figure 2.1 (A) the quantity of one characteristic Z_i is illustrated on the horizontal axis while the other characteristics are held fixed at a given level. Each consumer's bid contour represents a different level of utility. The level of utility increases as the price of the characteristic is reduced while holding constant the level of the other characteristics. Similarly, the offer functions of the sellers represent a level of profit that increases as the offer price increases, *ceteris paribus*. The offer functions are sloped upwards because additional units of characteristics can only be provided at higher offer

---

[3] Crouter (1987) tested the efficiency of water rights markets (that is , how separate water rights were from land prices) in Weld County Colorado by examining the linearity of the hedonic price function describing this market.

Figure 2.1
Implicit and Marginal Implicit Hedonic Price Functions

Figure 2.1
Implicit Hedonic Price Function

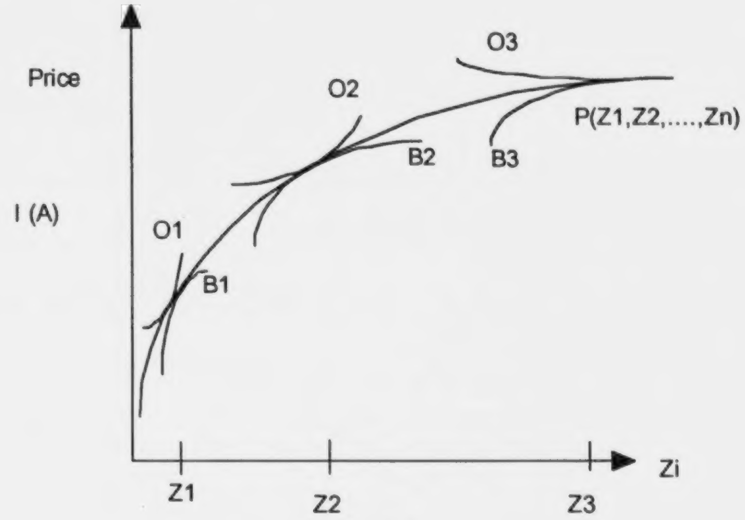
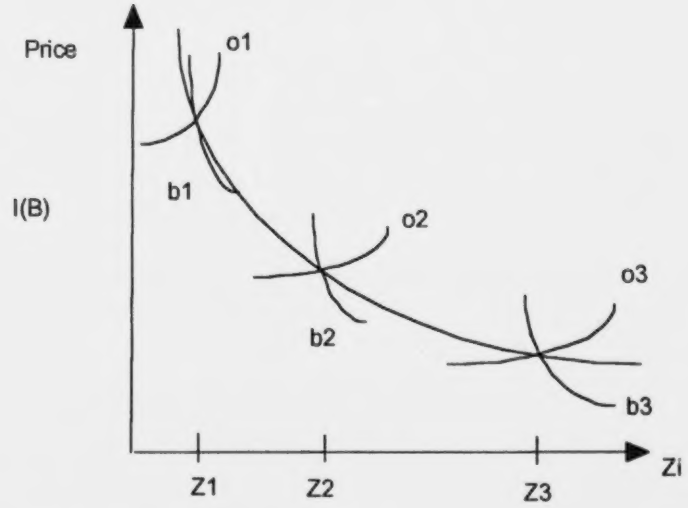

Price
I (A)
O3
O2
P(Z1,Z2,.....,Zn)
B2
B3
O1
B1
Zi
Z1
Z2
Z3

Figure 2.2
Marginal Implicit Price Function


Price
o1
I(B)
b1
o2
o3
b2
b3
Zi
Z1
Z2
Z3

Source: Anderson and Bishop 1986

prices if profits are to remain constant (Anderson and Bishop 1986). We assume that the offer function is convex since returns are expected to diminish at higher levels of production holding other characteristics constant. Profits are maximized by choosing that level of Z_i that places the firm on the highest possible offer curve. This will occur at the offer curve that is just tangent to the bid function at P(Z). For producer one this may occur at Z_1 in the Figure 2.1 (A). Other firms may choose different levels of characteristics as a result of different technical capabilities or different access to factor markets (Anderson and Bishop 1986). Buyers of characteristics seek to get on the lowest possible bid functions whereas sellers of the land seek to get on the highest possible offer function. Where a tangency between a bid and offer function is reached, a market transaction involving a specific Z vector occurs and a point on P(Z) is established (Anderson, 1986). The combination of all such transactions determines the full implicit price function P(Z), across all relevant bundles of characteristics (Anderson and Bishop 1986) (see Figure 2.1 (A)). It is assumed that there are enough buyers and sellers operating at each point along the implicit price function to maintain competition.

The implicit price function contains a number of marginal relationships as well. If we differentiate the bid and offer functions, then we will notice that the marginal bid and offer functions are equal at all the points of tangency along the implicit price function.

$$\partial O_i / \partial Z_i = \partial B_i / \partial Z_i \tag{2.2}$$

Therefore, at each level of Z_i, equilibrium outputs occur where the marginal bid equals marginal offer. These points are shown in Figure 2.1 (B). The marginal bid functions hold utility constant and express marginal willingness to pay for characteristics of the land. Therefore, the marginal bid functions can be interpreted as the Hicksian compensated demand functions for characteristics. Also, tracing out the points of intersection between the marginal bid and offer curves yields the marginal implicit price function and it follows that

$$P_{z_i}=\partial P(Z)/\partial Z_i \tag{2.3}$$

Armed with these concepts, it is clear how hedonic pricing could be applied to land values to determine the implicit value of water rights. The price of land could be regressed against site characteristics of the land such as access to irrigation water, soil type and depth, land topography, size of the building on the land (if there is any), distance to market and so forth. If we allow Z_1 to be the presence of a water right and $Z_2,\dots,Z_N$ to be other characteristics of the land, then P(Z) is the implicit price function for land values and the partial derivative of the price schedule with respect to Z_1 is the marginal value of access to irrigation water.

Some *a priori* requirements for P(Z) in the case of land values seem necessary. To begin with, if Z_1 measures the value of a water right to farmers in southern Alberta, then we would expect that P(Z) would have a positive or at least a nonnegative slope value. Furthermore, one would not expect P(Z) to be linear for land values since this would imply that the marginal willingness to pay for water rights is the same regardless of the soil conditions, climatic zone, or type of crop grown on the land plot. It would seem likely that marginal willingness to pay for an additional unit of water rights would decline as the level of irrigation increases. That is, a farmer who lives in a relatively dry area would be willing to pay more for water rights than a farmer living in a more humid area assuming that they are both growing the same crop.

2.3 Estimating the Hedonic Price Function

2.31 Explanatory Variables

We have seen above that the hedonic price function is a basic feature of the hedonic valuation method. Therefore, the specification of this equation is critical to hedonic pricing applications. Essentially any variable which influences consumers' utilities or producers' costs can be considered a candidate for inclusion in the hedonic function (Oczkowski, 1994). In other words the function is not limited to pure "quality" attributes (such as quality of soil); it can also encompass some "quantitative" attributes as well (such as value of buildings or distance to market). If the attribute is continuously measurable (quantitative), then the respective partial derivative of the function represents the implicit marginal attribute (Ockzkowski, 1994). If the attribute is not continuously measurable (qualitative), then a displacement of the consumption or production possibility frontier occurs and we have a clear theoretical interpretation of the coefficient (Oczkowski, 1994).[4] In this latter case, the partial derivatives are not clearly defined but estimates measure the impact of the presence of the attribute on the price of the variable (see for example Coelli *et al*,. 1991 and Williams *et al.*, 1993).

A number of conceptual and practical issues must be resolved in the course of selecting explanatory variables for inclusion in the hedonic model. These include (Freeman, 1993):

---

[4] See also Edmonds Jr., 1984, p.80-81 for more details on this.

Which measures of quality should be used to characterize quality variables? Is it possible to separate the effects of different amenities on the property values when the amenities are correlated? And do people's perception of the amenity levels correspond to the objective measures of amenity levels available to the researcher?

Since the objective of this analysis is to determine the effect of water rights on land values, other things being equal, a key issue is the control for other characteristics affecting land values. This is made more difficult by the likelihood of some multicollinearity occurring among different land characteristics. This, in turn, raises the question of the trade-off between increasing the bias in the model by omitting variables that are correlated with the variable of concern and decreasing the reliability of the coefficient estimates when collinear variables are included. Theory does not provide any hard-and-fast answers to this dilemma. The approach to this question may have to depend on the priorities of the researcher.

2.32 Functional Form

Economic theory rarely offers any strong guidance as to the correct functional form to be used so researchers have tended to regard the choice of functional form mainly as an empirical question to be decided on the basis of plausibility, goodness of fit and the like (Butler, 1982). Halvorsen and Pollakowski (1981) have suggested using a general functional form called the quadratic Box Cox. This functional form embodies many of the more popular functional forms as special cases including the trans-log, log-linear, quadratic, linear, generalized square root quadratic, generalized Leontief, and semi-log, among others (Palmquist, 1991).

Despite the flexibility of the quadratic Box-Cox functional form, it is very sensitive to different model specifications. Cropper, Deck and McConnell (1988) used simulated data to test the performance of various functional forms when the estimated hedonic equation was specified both correctly and incorrectly. They concluded that when the hedonic equation was specified correctly, the quadratic and linear Box Cox forms yielded the best estimates. However, when the hedonic equation was mis-specified because of proxied or unobserved variables, the simpler forms and linear Box Cox functional forms outperformed the quadratic and quadratic Box Cox functional forms in reliably predicting the implicit prices.

Graves *et al* (1988) unintentionally had similar findings. In a study investigating the value of urban air quality, they derived a wide range of estimates under alternative model specifications similar to that in Cropper *et al.* (1988). A mean predicted value of air quality was then estimated under several different functional forms and two slightly different sets of regressors. They discovered that, of the forms considered, it was the quadratic Box Cox that produced the greatest change in the predicted mean value of air quality when the regressor set is altered. In their conclusion they recommended the quadratic Box Cox functional form primarily because it provided the best “fit” to the sample data. However, it is clear that estimates derived from the quadratic Box Cox functional form are the most sensitive to changes in model specification.

A concise summary of arguments for and against the quadratic Box Cox can be found in Williams (1989). The overriding concern of the quadratic Box Cox is the sensitivity of its estimates to even slight changes in model specification. The primary concern in the present analysis is obtaining the most accurate estimation possible of the access to irrigation water attribute. The danger of obtaining poor estimates of this attribute due to moderate mis-specification problems has led us to consider the linear, log-linear and log-log functional forms only. Estimates will be provided using all three functional forms. The best fitting functional form of these three will be chosen using the Ramsey Reset test (Ramsey, 1969) and MacKinnon's modified J-test (1983).

2.4 Limitations of the Hedonic Price Model

2.41 Is the Market In Equilibrium?

It was mentioned above that if we take the partial derivative of the hedonic price function, we will obtain the marginal implicit price for a characteristic. According to Rosen (1974) these marginal implicit prices can be interpreted as the consumers' marginal willingness to pay for a particular attribute. This interpretation requires the assumption that each consumer has obtained the best possible price for their land and the price of each land plot just clears the market for a given stock of land. For these two aspects of equilibrium to be fully achieved, we require that consumers have full information on all land prices and attributes and that their transaction and moving costs be zero. In addition, we also require that the price vector adjusts instantaneously to changes in either demand or supply.

This idealized model is clearly not an accurate representation of real-world land markets. However, in order to evaluate the strength of this criticism of the hedonic model, we must focus on several distinct issues. The first concerns the accuracy of the price data itself. If the data available for estimating the hedonic function are based on assessments or appraisals, then they do not correspond to actual market prices. This error in measuring the dependent variable may obscure the relationship between property values and land characteristics. Estimates of this relationship may not be biased unless the errors themselves are correlated with other variables in the model (Freeman, 1993).

A second issue concerns the speed of adjustment of prices to changing demands and supplies of characteristics. If adjustment is not complete, then the observed marginal implicit prices will not reflect the marginal willingness to pay. But the question remains whether imperfect adjustment will lead to biases in estimates of willingness to pay. Increases in land prices may not affect marginal implicit prices of attributes. In this case no adjustment of the attribute bundles is necessary. Even if marginal implicit prices change, consumers will not react to this change unless the potential utility gain from doing so exceeds the information costs, transaction costs and moving costs associated with that change (Freeman, 1993). Therefore, we would expect some stickiness of consumers' reactions to changes in marginal implicit prices for characteristics. In other words, it may be reasonable to expect a band within which marginal implicit prices can vary from consumer household marginal willingness to pay for land attributes. If land prices change so that the marginal implicit price schedule for an attribute moves consistently in one direction, then consumers will consistently lag in their adjustment and the marginal willingness to pay will be overstated or understated depending on the direction of change (Freeman, 1993).

A third issue concerns expectations about future characteristic levels. Market prices for land reflect the discounted present value of the stream of expected future rents.

A change in expectations about future land characteristics can affect land prices and marginal implicit prices of characteristics independently of their present level. For instance, if there is a widespread expectation that water permits will become more scarce, the price differential between land plots with water rights and those without may increase. Correlating these prices with existing levels of irrigation water could lead to an underestimate of the marginal value of water rights.

To summarize, land markets that are not in full equilibrium do not pose a great problem for estimates of hedonic price functions. In most cases, markets that are not in equilibrium will only introduce random errors into the estimates of marginal willingness to pay. However, it should be noted that where market forces are moving continuously in one direction, or are expected to move in one direction, incomplete market adjustment can introduce biased estimates of marginal implicit prices.

2.42 Limited Range of Land Types

The implicit price function of the hedonic model is assumed to be continuous and differentiable. However, empirically this seems to be an artifact of the statistical and mathematical technique of the model (Freeman, 1993). If this assumption is not satisfied in practice, two problems can emerge. The first problem is that a statistically fitted hedonic price model will only be a good approximation if there are a large number of land plots included in the sample and there is continuous variation among the characteristics of the land parcels. The second type of problem arises if there are no land parcels available with a particular combination of characteristics. If there is a substantial gap between what consumers want and the land parcels that are available, then some consumers may not be able to maximize their utility and this could mean that the first order conditions of the implicit price function will not be satisfied.

This problem has been examined more closely in the literature on urban housing markets. Harrison and Rubinfeld (1978) estimated an implicit price function for housing in the Boston Metropolitan Statistical Area and the marginal willingness to pay as a function of nitrogen oxide levels and incomes. They discovered that some high income households experienced a large benefit by locating in a high nitrogen oxide area. This was a surprising result. Hedonic models used in studies such as this one imply that high income households should locate in low pollution areas and have a low marginal willingness to pay for additional air quality improvements. A possible explanation for this (Freeman, 1993) is that some high income households wished to consume bundles of housing with low nitrogen oxide levels and high levels of some other characteristics (such as cultural amenities of the urban environment) but there were no housing units available that offered both these characteristics together so households did the best they could by choosing homes in areas that were polluted but also had desirable qualities.

It is difficult to say how important this issue is in practice. The above example makes it clear that it cannot be ruled out on *a priori* grounds. In fact, it is almost certain that this problem will exist in certain subgroups of land types or areas. This does not mean that estimates of the hedonic model are so unreliable that they are of no use. It is certainly difficult for any model to perfectly replicate the situation of every component of the aggregate (Freeman, 1993). However, it is a problem to which empirical researchers must be sensitive. Careful examination of the data could be helpful in identifying the problem and its seriousness.

2.43 Market Segmentation

A question that has been raised frequently in the hedonic literature on housing prices is that of market segmentation. Strazheim (1974) was the first to argue that the urban housing market really consisted of a series of separate, compartmentalized markets with different hedonic price functions in each one. To support this hypothesis, he estimated separate hedonic price functions for different geographical areas of the San Francisco Bay area. He then showed that these estimates taken together had a lower sum of squared errors than one hedonic estimate taken of the entire San Francisco Bay area.

This may also present a problem for hedonic estimates of land values in rural areas. For different hedonic price functions to exist, two conditions must be met. The first is that the structure of the demand, the structure of the supply, or both, must be different across segments of the rural land market being studied (Freeman, 1993). This means that either the buyers of land in separate sub-markets have different structures of demands, or the structure of characteristics of the land parcels themselves are different from one sub-market to the next. The second condition is that land purchasers in one market segment must not participate significantly in other market segments (Freeman, 1993). In other words, there must be barriers to the mobility of buyers among market segments that prevent buyers from negotiating differences in marginal implicit prices between segments. These barriers could be due to geography or lack of information on the part of the buyers. Even with buyer immobility, if demand and supply are the same, they will produce similar structures of hedonic prices and perfect mobility and information on the part of the buyers will eliminate differences in the implicit prices for any characteristics of the land across market segments.

If market segmentation does exist, the hedonic price function estimated for the entire land area as a whole will produce faulty estimates of the implicit prices of characteristics facing buyers in different subsets of the market (Freeman, 1993). If this is the case, then separate hedonic price functions must be estimated for each market segment.

The existence of market segmentation does not invalidate the hedonic price technique. Instead, it makes the application of this technique much more difficult. If the market could be segmented, it would be conceptually possible to estimate separate implicit price functions for each market segment. Although these functions would be different across markets, they each would accurately represent the different marginal willingness to pay in each segment. Therefore, hedonic models could still be effective in estimating the marginal willingness to pay.

2.44 The Identification Problem

One of the greatest strengths of the hedonic price model lies in its potential for using estimates of individuals' marginal implicit prices for characteristics to help predict the underlying aggregate demand and supply for characteristics (Freeman, 1993).

Rosen (1974) argued that the demand and supply (or marginal willingness to pay and marginal supply) functions could be estimated from the information contained in the hedonic price function. To do this, he suggested a two stage approach. In the first stage, the implicit price equation is estimated using the best functional form available.

$$P_i=(Z_i)+u_i \qquad where\ i=1,\ldots,n \tag{2.4}$$

where P_i is the price of the i-th good (that is the i-th observation), Z is a kx1 vector of K characteristics of the i-th good and u_i is a random disturbance term. Then, in the second stage, a system of supply and demand are specified for each characteristic in the implicit price function.

$$Demand \qquad P_j=G_j(Z_i,Y_1)+V_j \quad where\ j=1,\ldots,k \tag{2.5}$$

$$Supply \qquad P_j=H_j(Z_i,Y_2)+W_j \quad where\ j=1,\ldots,k \tag{2.6}$$

P_j is the implicit marginal price estimated in the first stage and Y_1 and Y_2 are exogenous shift variables.

Once the hedonic price equation is estimated in the first stage, the marginal implicit prices of the characteristics can be calculated by taking the partial derivative of the price function with respect to the characteristic.

$$P_{z_i}=\partial P_i\ /\partial Z_i \tag{2.7}$$

These marginal implicit prices can be used in the second stage as endogenous variables in the supply and demand equations. That is, the P_j 's in the second stage would be replaced by the implicit price (P_{Zi}) estimated in the first stage. By treating these estimated marginal implicit prices as direct observations, Rosen contended that the second step is just a "garden variety identification problem" (1974, p.50).

This suggestion has been the source of a significant amount of literature for more than a decade. A number of economists (Brown and Rosen 1982, Parsons 1984, Epple 1987, Bartik 1987, and McConnell and Phipps 1987) have shown that the identification problem may not be as easily dispensed with as Rosen suggested.[5] Since this study is only an application of Rosen's "first stage," the issue of identification will not have to be dealt with. Therefore, the following discussion will only be an overview of the sources of the identification problem and the approaches to solving it.

The difficulties in identifying the supply and demand for characteristics from the hedonic price function comes in two forms. The first arises from the fact that the dependent variable in the supply and demand curves of Rosen's second stage are not direct observations of characteristic prices, rather, they are a calculation of the marginal implicit price of the characteristics from the hedonic price function (Brown and Rosen, 1982). Brown and Rosen (1982) contend that these constructed marginal attribute prices will not play the same role in estimation that direct observation on the prices would play if they were available. As Brown and Rosen (1982, p.176) put it,

> "Because ... constructed prices are created only from observed sample quantities, any new information that they may provide (i.e., any information beyond that already provided directly by observed sample quantities) can only come from *a priori* restrictions placed on the functional form of the price function. In the absence of such additional restrictions, second-stage estimation of the sort suggested by Rosen may only reproduce the information already provided by the first-stage estimation of the price function."

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[5] Additional contributions on this issue can be found in Quigley (1982), Murray (1983), Mendelson (1984), Horowitz (1987), Bartik and Smith (1987) and Palmquist (1991).

In Rosen's two stage estimation above (Equation 2.4, 2.5 and 2.6) we can see that the marginal implicit price calculated in the first stage (Equation 2.4) is a function of the same characteristics that are explanatory variables in the second stage (Equation 2.5 and 2.6). Therefore, since the second-stage estimation procedure does not utilize any new information beyond that already provided in the first-stage, the coefficients estimated in the second stage will only reproduce those estimated in the first (Brown and Rosen, 1982).

The second form of difficulty arises from the fact that the quantity of the characteristic and its marginal implicit price are both endogenous in the hedonic price model (Freeman, 1993). This is very different from a standard market model in which an individual faces an exogenous price and chooses his/her quantity. It is also unlike a quantity controlled market where quantity is given and the individual chooses a price. In the case of a nonlinear hedonic price function, the consumer must choose a marginal implicit price for a characteristic and its associated quantity. This simultaneous choice of the marginal willingness to pay and its associated quantity makes it very difficult to distinguish the effects of demand-shifters from the price-quantity relationship itself.

This problem can be illustrated more clearly by the following example from Bartik (1987, pp.84-85). Suppose we have two individuals who are identical in every observable way. That is, they have identical vectors of observed characteristics (Z) and identical demand traits (D) affecting their marginal bids. However, individual two consumes a higher level of a characteristic than individual one because he/she has a greater taste for it. Bartik contends that taste, as an unobserved demand shifter, is positively correlated with characteristic levels. In this case, OLS estimates of the common slope of these two consumers' marginal bid functions will be positively biased. As Palmquist (1991) stated, "the other marginal prices (on the individual's marginal willingness-to-pay function) are only observed for other individuals with other socio-economic characteristics and provide no information on the original consumer's bid for different quantities of the characteristic"(p.96).

There are a number of different approaches that have been suggested to achieve identification. One approach is to find truly exogenous variables to be used as instruments in the estimation of the marginal willingness to pay function (Anderson and Bishop 1986). Finding the appropriate instrumental variables for this task is not easy. Many empirical researchers using this method would be faced with the task of defending the exogeneity of their chosen variables. Another approach is to place restrictions on the functional form of the hedonic price equation (Brown and Rosen 1982). This method can be used to assure that conditions are met to identify the marginal willingness to pay function. An early example of this technique is seen in Quigley (1982). He assumed that his hedonic price function had a property of homotheticity between income and demand. This allowed him to separate the effects of income (or other demand shifters) and quantity change on the marginal willingness to pay for characteristics.

Another possibility is to assume that there is a characteristic in the marginal implicit price function that is not an argument in the marginal willingness-to-pay function for another characteristic (Freeman 1993). An example of this is to assume exogenous attribute supply (Anderson and Bishop 1986). This makes it possible to use the omitted characteristic as an instrument in the estimation of the marginal willingness to pay function.

The most reliable approach to solving the identification problem is to find cases where the marginal implicit prices vary independently of other demand-shift variables (Freeman 1993). Specifically, this means finding cases where individuals with the same income, preferences and other traits have different marginal implicit prices. This can only occur if similar individuals must choose their marginal implicit prices in separate segmented markets. This approach may be implemented by estimating separate hedonic price function for every market segment, using the same specification (Freeman, 1993). Then, the marginal implicit price faced by each individual is computed from the hedonic price function. These values can in turn be regressed on observed characteristics and exogenous demand shifters to obtain the uncompensated bid function (Freeman, 1993). Providing that there is sufficient variation across markets and there are no unobserved differences in preferences across markets, this method is the most likely one to give reliable and properly identified bid functions (Freeman, 1993).

2.5 Summary

The application of the hedonic technique to value characteristics of goods (or land) is potentially useful and is becoming more common. However, before applying this technique, researchers should be aware of a number of issues.

The first is the assumption of market equilibrium. It may be unrealistic to assume that consumers are fully informed and have zero transaction costs, but this does not affect the validity of the hedonic pricing model. Markets that are not in equilibrium may only introduce random errors into the estimates of marginal willingness to pay. However, if market forces are continually moving in one direction then biased estimates of the marginal implicit prices may result.

A second issue is the one of market segmentation. Hedonic pricing may work well for small localized changes in characteristic levels but it will work less well for changes that are large, particularly if broad areas are considered. This does not invalidate the hedonic technique, however, it may make its application more difficult. Careful examination of the data may help determine if market segmentation is present.

Finally, the last issue is the cost of resolving the identification problem. It is not always realistic to assume identical preferences and income. Also, achieving identification through market segmentation may substantially increase collection costs. In some cases, the use of several markets may force the researcher to restrict the specification of attributes to only those attributes which different markets have in common.

The theoretical issue in this study that is most concerning is the one of market segmentation. As we will see later, (Chapter 5) there may be *a priori* expectations that the demand for water may be greater in some areas within our sample than others. If this is the case, then our estimates of water right values may not be representative of the value of water rights in smaller sub-markets within our sample. This issue will be dealt with in greater detail in Chapter five.

CHAPTER 3

LITERATURE REVIEW OF RELATED HEDONIC STUDIES

3.1 Introduction

The hedonic approach has been used regularly in the analysis of land prices. The analyses that are of more interest, for the purposes of this study, are those analyses which have focused on the value of a particular attribute of agricultural land. These studies can be divided into two groups. The first group includes a number of studies that have attempted to measure the impact of soil conservation on the value of agricultural land including King and Sinden (1988), Ervin and Mill (1985), Gardner and Barrows (1985) and Miranowski and Hammes (1984). A second group of more recent studies have attempted to measure the affect of site characteristics on the value of rural land. Included in this group is a study by Xu, Mittlehammer and Barkley (1993) and a study oriented specifically towards water by Coelli *et al* (1991). In a similar fashion to these studies which focus on the value of soil conservation and various site characteristics, the hedonic technique is used in this study to estimate the value of a particular attribute of the rural land, namely the value of water rights. Therefore, these two groups of studies will be the focus of this literature review.

3.2 Studies Measuring the Value of Site Characteristics

3.21 Measuring the Contributions of Site Characteristics to the Value of Agricultural Land

A recent article by Xu, Mittelhammer, and Barkley (1993) examined the effects of different combinations and qualities of select site characteristics on the value of agricultural land in six regions of Washington state. The article incorporates a general hedonic form; however, it imposes a non-negativity constraint on the prices of land. In addition to this, a new conditional moment test is adapted for testing the appropriateness of the functional form of the hedonic price function. This test allows the analyst to determine if the basic hedonic model adequately accounts for any conditional expectations of land value affecting the market attributes of the land. The article also provides empirical estimates of the value of several land characteristics.

The authors gathered sales information on 928 land transactions occurring throughout six regions of Washington state. Detailed information was gathered on various characteristics of the land (such as total acres, capability classification of the land, size of pasture, proportion of acres irrigated by pivot sprinkler and rill irrigation), buildings and machinery on the land (size and description of buildings and value of equipment), and other socioeconomic characteristics of the land (such as distance to the nearest town or major centre). This information was then incorporated into the hedonic model where the price per acre of the land is regressed against the other attributes of the land.

The results of the study indicated a number of important things. First, recent improvements in the buildings on the land were found to contribute significantly to land values in Washington state. Second, land markets in Washington were found to be regional in character since hedonic price functions varied from one region to the next. Third, basic empirical models of land values provide adequate representations of conditional expectations of land prices, and statistical tests can be used to test for the adequacy of such models. Finally non-negative truncation of land prices may be necessary.

3.22 Hedonic Pricing for a Cost Benefit Analysis of a Public Water Supply Scheme

Coelli, Lloyd-Smith, Morrison and Thomas (1991) used the hedonic model to determine the implicit value that farmers place on having water available for on farm use in the central wheat belt of Western Australia. Coelli *et al* used data on 129 land sales recorded between March 1987 and June 1989 by the Valuer General's Office of Western Australia. Sixty two of the sales in this period were of farms connected to a regional water supply network (Comprehensive Water Supply Scheme). The study area was then divided into two areas - the Lakes Districts and the North East Districts and separate hedonic price functions were estimated for each.

A standard hedonic model of farm land values was used where the independent variables are the characteristics of a property including whether or not the property is connected to a regional Comprehensive Water Supply Scheme (hereafter termed Scheme).

The coefficient of Scheme in the two models represented the marginal implicit value of the Scheme water connection. The coefficient value was 0.0712 for data collected from the North Eastern district and 0.1847 for data collected from the Lakes District. These values were then multiplied by the mean land prices ($259 and $419) to provide average per hectare values of $18.49 and $77.39. Coelli *et al.* then further multiplied these figures by the mean areas (1278 ha and 1087 ha) to provide per farm values of $23 566 and $84 123 for water availability in the two districts. They attributed the large difference between the farm values in the different regions to several reasons such as variation in farming practices between regions and applicability of supply technology to each region.

The most important result of this study is that Coelli *et al* found the hedonic model to be an extremely useful tool for estimating the implicit value that farmers place on the right to access water.

3.3 Studies Measuring the Affect of Soil Conservation of the Value of Rural Land Prices

3.31 Influence of Soil Conservation on Farm Land Values

King and Sinden (1988) applied the hedonic price function to an Australian farm land market to determine whether and by how much changes in land conditions affect land prices. From this, they were able to determine whether the benefits of land improvement exceeded the costs of land improvement.

Sales information on 70 properties were gathered in the New South Wales region. This information contained data on production characteristics such as the average slope of the property, the size of the farm, the expected productivity of the wheat crop on the land, the percent of arable land on the property, the cost of soil conservation needed on the land and a measure of per annum soil loss on the land. Additional information relating to the buildings on the land and location characteristics of the land was also collected. Socio-economic information on the seller was also collected. This included factors such as the age of the seller, his/her relative investment skills, the planned future occupation of the seller (that is will he/she continue to farm), the proportion of the seller's property being sold and whether or not the seller had children to take over the farm.

The result of the study indicated that land condition was clearly important in the market place. In the market examined, the value of soil conservation was capitalized in the land values. Therefore, there did not appear to be any evidence that this market was undervaluing the benefits of soil conservation relative to the costs of undertaking necessary conservation practices to preserve the productivity of the soil.

3.32 The Impact of Soil Conservation Investments on Land Prices

In a similar study to King and Sinden (1988), Gardner and Barrows (1985) attempt to determine if soil conservation investments are capitalized into land prices. The implications of this research are that if soil conservation investments are being capitalized in land, market out comes will provide conservation incentives, thus it would not seem necessary to adopt public policies that control erosion on-site.

The study area for this research was in southwestern Wisconsin's Crawford and Vernon counties. Accurate data for 158 farmland transfers between 1977 and 1979 were collected. Prices were posited as a function of land and transaction characteristics such as size of land, value of improvements, percent of purchase down, interest rate, years to pay and others. The results of this study were surprisingly different from previous studies reviewed above. The authors found that conservation investment is generally not capitalized into farmland values. This conclusion is based on the fact that many of the variables used to measure the degree of erosion were insignificant in the specified model. This conclusion implies that public policy attempts to control on-site soil erosion may be warranted.

3.33 Agricultural Land Markets and Soil Erosion: Policy Relevance and Conceptual Issues

Ervin and Mill (1985) conducted a study to determine if soil erosion had any significant impact on farm land prices. The purpose of this study was to gain a better insight into the relationship between land prices, soil erosion and conservation investments.

A standard hedonic price function was used with price per acre as the dependent variable. Other variables such as the size of the farm, the assessed value of the buildings, the percentage of tilled land, a measure of soil productivity, a measure of soil erosion and distance to market were all included as independent variables in the model. The results of the study indicated that the market place incorporates the impact of erosion on the land into the price of the land.

3.34 Implicit Prices of Soil Characteristics for Farmland in Iowa

The study by Ervin and Mill is similar to an earlier work by Miranowski and Hammes (1984) which also attempted to determine if the rural land market properly accounted for investment in soil conservation. Similar to the other studies above, the authors did this by using the hedonic price function to estimate the implicit prices of soil loss and potential soil erosiveness.

The data used for this study came from cross-section observations for ninety nine counties in Iowa. These included observations on farm land pH levels, topsoil depth, and potential erosiveness (based on rainfall intensity, soil properties and length and steepness of slope). Average farmland prices per acre from a 1978 Iowa Value Survey were used for the dependent variable in the model.

Once again the results indicate that differences in soil characteristics are reflected in farmland prices. This conclusion is based on the result that all indicators of soil quality (pH, soil depth and potential erosiveness) had significant effects on the value of land prices.

3.4 Summary

It is clear that there are a number of different factors that can be involved in determining rural land values. Dunford et al. (1985) identified the following main categories: external forces, expectations about future conditions, seller characteristics, buyer characteristics and land characteristics. The external forces include both economic and government forces that can affect the profitability of the farm. These can include interest rates, subsidy programs and foreign exchange rates among others.

The expectations about future conditions can include any expectations about future price, yields, costs, population size, distribution of urban sprawl into rural areas, re-zoning and changes to road or rail access (Coelli *et al.*, 1991). The characteristics of the buyers and sellers relate to the individual attributes of buyers and sellers that may affect the buyers' bid function and the sellers' offer function. King and Sinden (1988) identify these as any factors influencing farmer incomes, production levels, or utility functions. These can include such things as age, the investment skill of the farmer, whether the sale was forced or not, or whether the buyer was a close neighbour or relative. (Coelli *et al.*, 1991).

The first two categories of Dunford's factors, external forces and expectations, are most relevant for temporal or wide ranging spatial analysis (Coelli et al, 1991). The third and fourth categories of buyer and seller characteristics are more relevant to studies intent on proceeding to Rosen's second stage. The last category of Dunford's five categories is the one of most interest to this study. This is the category relating to specific characteristics of individual farms. These characteristics include soil quality, area of cultivation, value of buildings and improvements (in particular, if access to water is present on the land), locational characteristics and other physical traits of the land. These characteristics and others will be the focus of the model specified in the next chapter.

CHAPTER 4

METHODOLOGY AND MODEL SPECIFICATION

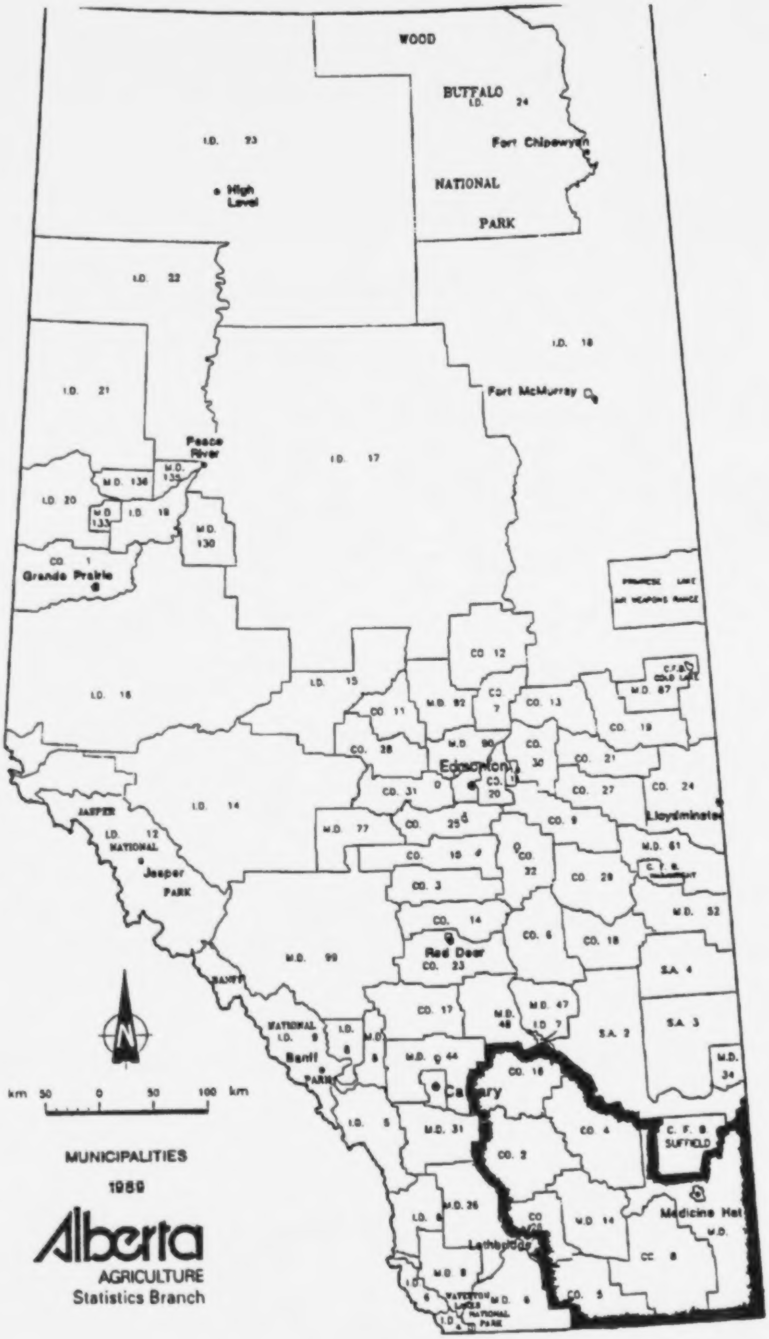
4.1 Introduction

In this section, the study area, the data sources, the data limitations and the methodology used to specify the hedonic price model of this study are all described. Data from Land Information Alberta and county land assessors are used to develop both the dependent and independent variables of the hedonic model. Problems of a methodological nature which have their origins in the data are also discussed in this section.

4.2 Area of Study

The region chosen for this study, (Figure 4.1), is located in south eastern Alberta encompassing the counties of Wheatland, Newell, Medicine Hat, Forty Mile, Taber, Warner, Lethbridge and Vulcan. This area was chosen because data were easily accessible and it represents one of the most heavily irrigated regions in the nation. In 1992, the 13 irrigation districts located in southern Alberta had 1.22 million acres assessed as irrigable with 1.09 million acres actually irrigated (Alberta Agriculture 1993). This accounts for almost two-thirds of the irrigated land base in Canada. The crops grown in this area are highly diverse. The main crops grown under irrigation are cereal grains followed by hay, oilseeds, and specialty crops such as peas, corn, beans, timothy, alfalfa seed, sweet clover seed, small seeds and miscellaneous crops (Alberta Agriculture 1993).

Figure 4.1
County Areas Included in Study


WOOD
BUFFALO
I.D. 24
NATIONAL
PARK
Fort Chipewyan
I.D. 23
High Level
I.D. 22
I.D. 18
Fort McMurray
I.D. 21
Peace River
I.D. 17
M.D. 136
M.D. 135
I.D. 20
M.D. 133
I.D. 19
M.D. 130
CO. 1
Grande Prairie
PRIMROSE LAKE AIR WEAPONS RANGE
CO 12
C.F.B. COLD LAKE
M.D. 87
I.D. 16
I.D. 15
CO. 11
M.D. 92
CO. 7
CO. 13
CO. 19
CO. 28
M.D. 90
CO. 30
CO. 21
Edmonton
CO. 20
CO. 31
CO. 27
CO. 24
Lloydminster
JASPER
I.D. 14
M.D. 77
CO. 25
CO. 9
I.D. 12
NATIONAL
Jasper
PARK
CO. 10
CO. 32
M.D. 61
CO. 3
CO. 29
C.F.B.
CO. 14
M.D. 52
CO. 6
CO. 18
Red Deer
CO. 23
M.D. 99
S.A. 4
BANFF
CO. 17
M.D. 48
M.D. 47
I.D. 7
S.A. 2
S.A. 3
NATIONAL
I.D. 9
I.D. 8
Banff
PARK
M.D. 44
Calgary
CO. 16
M.D. 34
km 50 0 50 100 km
I.D. 5
M.D. 31
CO. 4
C.F.B. SUFFIELD
CO. 2
MUNICIPALITIES
1989
Alberta
AGRICULTURE
Statistics Branch
I.D. 6
M.D. 26
CO 26
M.D. 14
Medicine Hat
M.D. 1
Lethbridge
M.D. 9
CO. 8
I.D. 4
WATERTON LAKES NATIONAL PARK
M.D. 6
CO. 5

4.3 Data

The data used for this study was collected in two stages. In the first stage, information was collected from Land Information on the total sale value of land, the per acre sale value of the land, the size of the land and the Canadian Land Inventory Classification.[6] In the second stage, information was collected from county land assessors on the characteristics of each parcel such as the size of the pasture, the soil type, the soil depth, distance to market and the size of the nearest market, the average annual rainfall and, most importantly, the presence or absence of irrigation on the parcel. The data collected in these two stages were used as a basis for the hedonic model developed later in this study. A print out of all the data collected can be found in Appendix C.

4.31 Land Information Alberta

Land Information Alberta maintains, updates and on a monthly basis, produces and distributes computer listings of all the land title changes occurring during the year in Alberta.[7] Changes to a title can occur for any number of reasons. A change in name of the person(s) owning the title, a transfer into the name of an executor of an estate, a transfer of provincial crown land to private ownership, and a transfer from a seller to a buyer (Bye, 1983). If a title has been transferred due to a sale, the total sale value will appear on this listing. The listing also includes information (Bye, 1983) such as:

1. The legal description of the land (meridian, range township)

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[6] The Canadian Land Inventory Classification (C.L.I.) Indicates the main soil capability class in each quarter section in a title. The classes range from 1 to 7 with 1 being the best soil and 7 being soil that is not adequate for cultivation.

[7] This listing does not include title changes for Edmonton and Calgary.

2. Plan number

3. Block number

4. Lot number

5. Number of lots

6. Land use (indicates the use of a parcel other than normal residential or farming uses)

7. Size of parcel in acres

8. Certificate of title number

9. Portion code (refers to part of a block or lot involved in the change)

10. Status code (provides ownership status other than a private individual)

11. Interest (indicates extent of ownership by those listed on the change form)

12. Canadian Land Inventory Classification (indicates the main soil capability class in each quarter)

13. Consideration value per acre (per acre sale value)

14. Consideration value (total sale value)

This information was collected on all land sales occurring in the counties of Wheatland, Newell, Forty Mile, Taber, Lethbridge, Vulcan, Warner and the municipal district of Cypress. These counties encompass parts of the Eastern and Western Irrigation Districts, the St. Mary's Irrigation District, the Taber Irrigation District and the Lethbridge Northern Irrigation District.

All the sales data collected for this study occurred between January 1993 and February 1994. At the time of the observations, the price of cattle was at an all time high (Alberta Agriculture 1993). This may have made land in the counties of Lethbridge and

Newell more attractive since there is a high concentration of feetlot operations in these areas (Alberta Agriculture 1993). During this same year, the price of specialty crops such as corn for grain, dry peas and mustard were on a downward slide that had begun four years previously (Alberta Agriculture 1993). In the grains, the price of all wheats (including spring wheat, durum wheat and winter wheat) had risen for the fourth year in a row, however it was still below the level it was at in 1990 (Alberta Agriculture 1993). The prices of oats and barley were also down from previous years. The only bright spot appeared to be the prices of canola and rye which had risen for the fourth year in a row (Alberta Agriculture 1993). The low price of specialty crops combined with the relatively low price of grains may have lowered the demand for land in areas such as the counties of Taber, Forty Mile and Cypress.

The Land Title Changes List includes all changes in land ownership. It does not differentiate between land used for residential or farming purposes. In this study we are primarily interested in the impact that irrigation has on the value of agricultural land, therefore, the acceptable title changes were restricted to parcels of over one hundred acres. This left us with a total of 415 land sales initially eligible for inclusion in our study.

The quality of land involved in these sales ranged any where from very good (C.L.I. classification of 1,2 or 3) to very poor (C.L.I. classification of 4 or below). Land that is likely to be irrigated has a C.L.I. classification of 1, 2, or 3. In order to gain a better indication of the impact of irrigation on land values, *ceteris paribus*, it was important to compare irrigated and non-irrigated land that is similar in quality. For this reason, the number of acceptable title changes was limited further to those with a C.L.I. classification of 1, 2, or 3. This reduced our sample further to 230 land sales. Out of these sales, 37 occurred in the county of Wheatland, 46 were in the county of Vulcan, 32 were in the county of Warner, 36 were in Lethbridge, 25 were in Taber, 28 were in Newell, 17 were in Forty Mile and only 8 were in the county of Cypress.

The average size of a land parcel in our sample is 144 acres. None of land parcels included on the title change listing exceeded 160 acres (or a quarter section). In cases where a larger parcel was sold, such as 320 acres (half section) or 640 acres (whole section), the sale price was divided evenly between the quarter sections making up the parcel. The average parcel in this sample sold for $648 per acre. If we multiply this by the average parcel area, then the average land parcel sold for approximately $93 312 in our sample.

4.32 Land Assessors

In the second stage of the data collection, additional information on the physical characteristics of each land parcel collected in stage one was obtained from the county land assessors. Under division one of the Assessment Act, county assessors are required to assess the value of all land parcels in their municipality each year.[8] The information they gather is summarized on field sheets similar to the one in Appendix A. Included on these sheets are ratings on the soil group, soil depth, soil texture, topography, and degree of stoniness of the land parcel. These rating factors are established by the assessors to determine the productive value of each of these characteristics. A rating factor of 1.00 is the optimum condition indicating that the characteristic does not inhibit the productive value of the land. Less than optimum conditions have lower ratings depending on how severely the condition of the land characteristic affects yield. For example, in soil groups black soils have a rating factor of 1.00, the thin black soils are rated at .85, the dark brown soils at 0.7, brown at 0.45, dark gray at 0.85, dark gray wooded at 0.7, and gray wooded at 0.6. A more precise summary of the methodology land assessors use to rate these different land characteristics is provided in Appendix A.

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[8] *Discussion Draft Assessment Act,* Legislation Paper, Municipal Statutes Review Committee. 1991

When all of the characteristics of the soil (soil group, soil colour, soil depth, soil texture, topography of land and degree of stones present in top soil) are given a rating, the assessors then compute a "productivity rating" which relates that particular soil to other soils in the province. This productivity rating is then converted to a value used for assessment purposes by applying it to a Basic Rate dollar value per acre. The rating process is applied on a quarter section basis and the value obtained is then further conditioned by applying additional "location rating" factors which are dependent on the location of the land with respect to urban centres and roads. This calculation determines the 1977 Basic Value of the parcel. Detailed information on the methods land assessors use to determine the value of a land parcel is also provided in Appendix A.

4.33 Value of Improvements

Land assessors often do not assess the value of any improvements which may be considered tax exempt. Therefore, very little information is available from the assessors on the value of buildings or improvements on the various parcels. In Alberta, farm land is not traded separately from the structures placed upon it, so observed sale prices may sometimes reflect the values of both the land and its structural improvements. This does not present any problems at the theoretical level but it does require that the hedonic price equation adequately control for the value of structural characteristics.

The contributory value of buildings to the price of the land can often be obscured by market forces. The economic health of an industry may be an important factor in determining what people will pay for buildings. For instance, buyers may pay close to the replacement cost for old buildings on a beef farm regardless of how old these buildings are if they perceive the economic health of the industry to be high and provided the buildings are functional for the use intended. On the other hand, a new multi-layered poultry building may be worthless if poultry prices are depressed and the buyer plans to switch to another kind of operation. These factors make it extremely difficult to determine the value that buyers may place on buildings in every sale.[9]

It is possible to gain a reasonable estimate of the contributory value of buildings by using a sales comparison approach.[10] This approach involves comparing sales with improvements with bare land sales in an area to determine the contributory value of buildings. Many factors such as the soil type, texture, topography, stoniness, the productive potential and the location of the land were considered when comparing sales. Therefore, whenever a land sale involved improvements, the contributory value of those improvements could be estimated by subtracting the value of bare land sales in the area from the total sale price of the land. The difference is seen as the contributory value of real estate improvements to the sale price of the land further details of this method can be seen in Appendix B.

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[9] A survey of all the buyers and sellers in the land market would be a better way to determine this. This issue will be discussed later in Chapter Six.

[10] The idea for the sales comparison approach originally came from Gary Shufeld of the Farm Credit Corporation. I am grateful for his assistance in this area.

4.4 Specifying A Hedonic Price Function for Water Rights

From the information supplied by Land Information Alberta and the county land assessors, the following variables were specified:

AREA - area of cultivated land (acres)

PRICE - price per acre of land (dollars $)

WATER - farm land has access to irrigation water (1=yes, 0=no)[11]

BUILD - estimated contributory value of buildings to sale price.

PASTURE - area of land that is in pasture (acres)

DBR - indicates that land has dark brown soil (1=yes, 0=no)

TB - indicates that land has thin black soil (1=yes, 0=no)

WDBR - indicates that land is irrigated and has dark brown soil (1=yes, 0=otherwise)

WTB - indicates that land is irrigated and has thin black soil (1=yes, 0=otherwise)

SOILDEPT - depth of top soil on land (inches).

VGS - indicates that topography of land is very gently sloping (1=yes, 0=no)

VGU - indicates that topography of land is very gently undulating

STONES - indicates the presence of stones on the land (1=yes, 0=no)

DIST - distance to nearest market (km)

VLC - nearest market is a very large city (Calgary) (1=yes, 0=otherwise)

LC - nearest market is a large city (Lethbridge) (1=yes, 0=otherwise)

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[11] Some farms may use irrigation water for pasture or small areas designated to specialty crops. In cases such as this, having access to irrigation water may not significantly impact the value of the farm. Therefore, only farms that were irrigating 100 acres or more were considered as having access to irrigation water.

MC - nearest market is a medium sized city (Medicine Hat) (1=yes, 0=otherwise)

LT - nearest market is a large town (1=yes, 0=otherwise)

AT - nearest market is an averaged sized town (1=yes, 0=otherwise)

DISTRD - distance to the nearest paved road (km)

HOME - Producer's home is located on land parcel (1=yes, 0=no)

CANAL - direct access to irrigation canal (1=yes, 0=otherwise)

RAIN - average annual rainfall (mm)

The variables in this model can be divided into three categories: those influencing the productivity of the land, those influencing the consumption of the land and those influencing both production and consumption. In the first category is AREA, PASTURE, WATER, DBR, TB, WDBR, WTB, LEVEL, VGS, VGU, SOILDEPT, STONES, RAIN; in the second we place HOME and in the third are the remaining variables DIST, VLC, LC, MC, LT, AT, DISTRD, CANAL and BUILD.

4.41 Production Characteristics

In smaller and average sized farm operations the relationship between PRICE and AREA is expected to be negative. This expectation is based on the premise that in more productive areas (i.e. areas with more productive soils and higher rainfall) the farms tend to be smaller because land is more expensive and less land is needed to meet production levels (Coelli et al, 1991). Other factors may also influence the relationship between farm size and price per acre. For example, there are generally a larger number of buyers that can afford smaller parcels of land in the market place (Coelli et al, 1991) and this may also contribute to the negative relationship between PRICE and AREA. There is a possibility of the conflicting influence of economies of scale on the coefficient of area (Coelli et al. 1991) but it is unlikely that this will overpower the other effects. As farm areas become very large, the relationship between PRICE and AREA may eventually become linear or positive; however, it is likely that the farm parcels in our sample are too small for this to occur.

PASTURE is a measure of the area of pasture land on a farm. Farms with large areas of pasture are considered to be less productive for cultivation purposes and this may reduce the price of the farm. Therefore, the expected relationship between the PRICE and PASTURE variables is expected to be negative.

The variable of most interest to this study is WATER, a dummy variable which indicates whether a farm has access to irrigation water or not. If a farm has access to irrigation water, irrigation can occur throughout the season and moisture is not a limiting factor to crop yields. Irrigation is particularly important for the profitability of the specialty crops grown in the irrigation districts which are the focus of this study. The variable of WATER is represented as a dummy variable indicating by 1 if there is access to irrigation water on the land and 0 if there is not. Having access to irrigation water is expected to have a positive influence on land prices. A crude comparison of the value of irrigated agricultural land and non-irrigated agricultural land in our sample reveals that irrigated land is worth, on average, $324.53 more per acre than non-irrigated land.

The type of soil found on a land parcel can greatly affect its productivity. Generally, darker soil types are considered more productive than lighter soils. Darker soils, found primarily in more humid regions of the province, have a greater accumulation of decomposed organic matter. Lighter soils have less vegetative residue and these soils are usually found in the more arid regions such as the short grass prairie regions of southern Alberta. Soil colour, in combination with texture, determines how easily fine particles are eroded from the surface of the soil and how rapidly moisture is absorbed. There are a total of six different soil zones found in Alberta; however, only three of these can be found in our study area: the brown (BR), dark brown (DBR) and thin black soils (TB). These variables are all specified as dummy variables. In the absence of irrigation, brown soils are the least productive soil group assuming that soil texture is held constant. Therefore, this has been chosen as the base case to which other dummy variables are compared. Thus, the interpretation of the coefficients on DBR and TB will be done in relation to brown soils.

WDBR and WTB are interactive variables that are intended to capture the relationship between irrigation and dark brown soils (WDBR) and irrigation and thin black soils (WTB). Generally, irrigation is preferred on soils that allow rapid absorption and downward movement of moisture. Soil colour in combination with texture is expected to reflect soil suitability for irrigation. Soil groups that are most suited for irrigation may command a higher price than other soils less suited to irrigation. WDBR and WTB are also specified as dummy variables and their respective coefficients will be interpreted in relation to the case of brown irrigated soils.

SOILDEPT refers to the depth of the top soil (inches) under natural conditions (i.e. before plowing and erosion associated with cultivation). Deeper top soils are associated with more productive land. Therefore, the relationship between SOILDEPT and PRICE is expected to be positive.

Soil texture refers to the relative proportions of sand, silt and clay particles in the soil mass. The texture of the soil is closely related to other soil properties such as its ability to hold moisture, its power of cohesion, its ease of cultivation etc. County land assessors have classified soil textures as gravel, sand, silt, clay or, more commonly, as a combination of these such as loam, sandy loam, clay loam and silt loam. There are nineteen soil textural classes in total and rating factors exist for each of these different groups (Alberta Municipal Affairs 1979).

Incorporating soil texture into our model more directly than through the soil colour-irrigation interaction term discussed above would be a difficult task. Dummy variables could be used to represent all of the different soil textural classes but this would likely make our model too large and cumbersome and it is not clear which classification could be used as an appropriate base case. Rating factors have been established by land assessors for each soil textural class but these ratings do not have any economic interpretation unless assumptions are made regarding the marginal relationships between the different rating factors. Also, soil texture is rated differently for irrigated and non-irrigated soil. For instance, soil textures that allow rapid absorption and downward movement of moisture will be given a higher rating on irrigated soils than non-irrigated soils. Soil texture could only be included in the model if a common scale existed that rated irrigated and non-irrigated soil texture consistently. Time and funding restrictions prevented us from doing this; therefore, soil texture was not included as an explanatory variable in the model even though it is believed to be important.

Topography can influence crop production by reducing yield and increasing operation costs. Yields can be reduced if the land topography is rough or hilly. The tops of hills often have shallower, less fertile soils, and are generally drier than the remainder of the fields since moisture runs off the hills. Also, if water accumulates in low lying areas this could delay seeding and cause uneven ripening in the field. Rough topography can also increase operating costs. Sloughs or wet areas require more turns and overlapping of work by farm machinery. Often special practices must be followed on rough topography to reduce soil erosion by water.

There are eight different classes of topography recognized by land assessors in Alberta. These include flat or depressional, level, very gently sloping, very gently undulating, gently undulating, undulating, roughly undulating and very roughly undulating. The topographical types are very homogenous across the study area as only three different types of topography are observed: level, very gently sloping (VGS) and very gently undulating (VGU) (Alberta Municipal Affairs 1979). Preliminary analysis indicates that the topography within our study area does not vary enough to warrant inclusion in our model.

The presence of stones (STONES) can affect yield but the chief concern is the effect on operating costs resulting from tillage difficulties, damage to machinery, cost of removal etc. Generally, wherever stones are found, they occur throughout the soil profile; however, in certain cases stones are only located on the surface. In the latter case, the task of removing stones is a rather minor one since the land will be relatively stone free once the stones have been removed. If the stones occur throughout the profile, they will be continually forced to the surface by natural causes or dragged up by machinery. In this case, stone removal will become a yearly task. All of these factors are considered by land assessors when they set up their rating schedule for stones. There are four classes of stones: no stones, slight to moderate stones, serious stones, very serious stones and unsuitable for cultivation. The land in our sample generally has few stones which are a major handicap. Only two classes of stones are found in our sample: no stones and slight to moderate stones. Therefore, the variable STONES has been specified as a dummy variable indicating 1 if there are stones on the land and 0 otherwise.

The last variable that is expected to affect the productivity of the land is the average annual rainfall (RAIN). Rainfall can be a limiting factor to productivity in Alberta, particularly in the arid south east. The average annual rainfall in the study area is approximately 400 mm per year. Low rainfall can adversely affect yields on non-irrigated land parcels. Therefore this may have an impact on land prices. However, since the climatic conditions of the counties within our study area are roughly similar, RAIN may not have a significant impact on land prices.

4.42 Consumption Characteristics

The only variable included in this group is HOME. This has been specified as a dummy variable indicating whether the seller's home is located on the property. It is expected to have a positive influence on farm values.

4.43 Characteristics Influencing Both Production and Consumption

DIST is used in our model to specify the distance in miles that each property is from the nearest market. Location can have a strong effect on the value of the land parcel. Land parcels located close to urban centres have better access to market (where crops may be sold), shopping, cultural, recreational and school facilities. It is expected that the relationship between DIST and PRICE will be a negative one since it is reasonable to assume that the further a land parcel is from the nearest market the less it is likely to be worth.

The size of the nearest market can also greatly impact the value of a farm. For example, farm areas located close to Calgary are expected to be worth more than farms located next to Foremost. Land assessors have classed each city, town and village according to its size and relative advantage it provides to the rural population (i.e. according to its marketing, shopping, cultural, recreational and school facilities). There are six classes of markets: very large city (VLC), large city (LC), medium city (MC), large town (LT), average town (AT) and small town. These have all been specified as dummy variables. The coefficients of these variables will all be interpreted in relation to the base case of the nearest market being a small town.

Access to a road can also influence the value of the farm land. Farmers can get their product to market more quickly and easily if they have good access to a road. If machinery and trucks are damaged or prematurely worn down by rough surfaces, this will make the farm land less desirable. Once again the relationship between distance to the road (DISTRD) and PRICE is expected to be negative. Distance to road (DISTRD) is specified as the number of miles to the nearest good quality road.

Farm land that has main irrigation canals running through or adjacent to it may be less valuable. Seepage from older canals may cause water logging in the immediate areas around the canal and this in turn could raise salinity levels. The presence of canals on the land may also increase operating costs on farms if more passes are required by machinery to cultivate land around the canal. The variable CANAL is specified as a dummy variable indicating whether or not an irrigation canal is present or adjacent to the land.

Finally, in an earlier section it was noted that land prices can reflect the value of the bare land as well as the value of the buildings located on it. Nearly 42 percent of the land parcels in our sample have buildings on them. Therefore, it is important to include the estimated contributory value of buildings (BUILD) as an explanatory variable in our model. BUILD is specified as the contributory value of buildings to the value of each land parcel. Originally BUILD was specified as a dummy variable indicating whether there were buildings on the land (yes=1) or not (no=0). Preliminary results indicated that there was significant correlation between the dummy variable BUILD and WATER. This correlation may have existed since irrigated land requires additional equipment and buildings to store this equipment. Since the primary concern of this study was to ensure that WATER is estimated as accurately as possible, BUILD was specified as a continuos variable (see above) and not a dummy variable.

4.44 The Model

Equation 4.1 and 4.2 below summarize the specification of the hedonic model used in this study.

$$\begin{aligned} Price = f(&AREA, WATER, BUILD, PASTURE, DBR, TB, WDBR, WTB, SOILDEPT, \\ &STONES, DIST, VLC, LC, MC, LT, AT, DISTRD, CANAL, RAIN) \end{aligned} \tag{4.1}$$

$$\begin{aligned} Price = {} & \beta_0 + \beta_1(AREA) + \beta_2(WATER) + \beta_3(BUILD) + \beta_4(PASTURE) + \\ & \beta_5(DBR) + \beta_6(TB) + \beta_7(WATER)(DBR) + \beta_8(WATER)(TB) + \\ & \beta_9(SOILDEPT) + \beta_{10}(STONES) + \beta_{11}(DIST) + \beta_{12}(VLC) + \\ & \beta_{13}(LC) + \beta_{14}(MC) + \beta_{15}(LT) + \beta_{16}(AT) + \beta_{17}(DISTRD) + \\ & \beta_{18}(CANAL) + \beta_{19}(HOME) + \beta_{20}(RAIN) + \epsilon \end{aligned} \tag{4.2}$$

The results of estimating the above model will be provided in the next chapter.

4.5 Summary

The data used in this analysis were essentially collected in two stages. In the first stage, information on sale values of land were collected from Land Information Alberta and these data were used to develop the dependent variable PRICE in our model. In the second stage, additional information on the production and consumption characteristics of the land were collected from field sheets provided by county land assessors. This information was used to develop the explanatory variables of our hedonic price model.

Some of the methological difficulties in developing the hedonic price model in this analysis are inherent in the data itself. To begin with, the rating factors used by land assessors did not have any direct economic interpretation. To avoid imposing restrictions on the marginal relationship between rating factors, dummy variables had to be used in many cases to attach economic meaning to many of the land characteristics. The impact of soil texture on land prices had to be ignored completely because the rating scale used to assess the relative value of soil texture could not be adapted for our purposes. Finally, no information was available on the contributory value of buildings or improvements on the value of land prices. This would be a serious omission from our model since land values often include the value of buildings placed on it. To compensate for this, a sales comparison approach was adopted to estimate the contributory value of buildings in each sale.

Despite these difficulties the hedonic model used in this analysis includes many of the important variables seen in other hedonic land-based studies similar to this one (Xu, Mittelhammer, and Barkley, 1993; Coelli et al , 1991; King and Sinden, 1988; Ervin and Mill, 1985; Gardner and Barrows, 1985 and Miranowski and Hammes, 1984). Therefore, it should provide a reasonable estimation of the value of water rights.

CHAPTER 5

THE EMPIRICAL RESULTS

5.1 Introduction

The hedonic model and variables described in the previous chapter can be used to estimate farmland values in both the study area and the smaller counties within this area. Earlier it was hypothesized that hedonic price functions may not apply across a large diverse area containing a number of smaller distinguishable market segments (refer to Chapter Two). This could be due to inherent differences in soil and water availability which could cause farming practices to vary from one region to the next. Therefore, the empirical results in this section will be presented in two parts. The first section presents results for the larger study area considered. Various forms of the hedonic function will be estimated to determine which variables have a statistically significant influence on farmland values and thus add to the explanatory power of the model. In the second section, empirical results will then be presented for each individual county. Statistical interpretations and economic inferences of the results are made to provide a basis for economic conclusions and economic implications which are discussed in Chapter Six.

5.2 Estimation of the Model

Price per acre has been used in favour of total price as the dependent variable in this analysis for intuitive reasons. Farmers and property agents usually express property values in per acre rather than per farm terms since farm sizes often vary. Preliminary analysis of the data further supports the choice of price per acre as a dependent variable as total price exhibits a significant amount of heteroscedasticity.

The basic model described in equation 4.2 in the previous chapter was estimated using our cross section sample of 230 observed land sales. Some degree of multicollinearity was expected in this model, particularly between variables such as BUILD and HOME. To determine how serious the problem is, the correlation coefficients between each of the property attributes were calculated and the results are listed in Table 5.1. All those correlations that exceeded the arbitrarily chosen value of 0.4 are included in this table.

TABLE 5.1
Sample Correlation Coefficients Between Attributes

Attribute A	Attribute B	Correlation
HOME	BUILD	0.45654
RAIN	TB	0.63887
RAIN	DBR	0.49967
WDBR	DBR	0.48647
WDBR	SOILDEPT	0.51633
SOILDEPT	DBR	0.66229
VLC	DIST	0.68704
WDBR	WATER	0.51266

The expected correlation between BUILD and HOME is certainly present. It is not surprising that in most cases the value of buildings on the land will often include the value of the farmer's home as well. Additional correlation also exists between RAIN, TB and DBR. It was mentioned earlier that soil colour is generally a function of average percipitation levels (See Chapter 4). Darker soils are generally associated with higher precipitation levels. Therefore, it appears that this result is reasonable. The correlation between WDBR and DBR is not surprising since WDBR is an interaction term including DBR.

Darker colored soil such as the dark brown and thin black soils often have a thicker top soil than the lighter coloured soil such as the brown soils. This may help explain the positive correlation that exists between WDBR and SOILDEPT as well as SOILDEPT and DBR. There didn't appear to be any strong correlation between SOILDEPT and TB or WTB; however, this may be due to the fact that very few of the land plots in the data set had thin black soil.

Strong correlation also appears to exist between VLC and DIST. This relationship may be an artifact of the data. VLC indicates that the nearest market to the farm site is Calgary. All of the land parcels located in the county of Wheatland were considered to have Calgary as its nearest market even though some of the land parcels are located 50 to 100 km from Calgary. This was done because Calgary is a larger city and has a more far reaching affect on land prices than smaller centres may have. Therefore, farms that have Calgary as the nearest market may be located a significant distance from this city. As a result, this may have contributed to the positive correlation between VLC and DIST.

The remaining correlation in the model exists between WDBR and WATER. This correlation is not surprising since WDBR is an interaction term of the WATER variable and DBR. However, since the main focus of this study is to determine an accurate estimate of WATER, WDBR was taken out of the model. The collinearity problem occurring between the other variables was not acted on at this stage since, as it will soon be seen, none of these variables were significant enough to be included in the preferred model.

Ordinary Least Square (OLS) estimates of the Linear, Log-Linear and Log -Log functional forms are presented in Table 5.2. The F-values for all the functional forms are significant at the 5 percent level of significance indicating that all the models are significant over-all. The Ramsey Reset test (Ramsey ,1969) was performed on all of the functional forms. The Ramsey Reset test is a general test of model mis-specification where predicted values of a model are estimated, then squared, cubed etc. and substituted back into the original model. The idea is that if the model is specified correctly in the first case, adding the predicted value in another form will not improve the model very much. F-values are calculated by comparing R squared values from the original model to the new model with the predicted values included. If the models are dramatically improved by adding the predicted values to it, the F-values will be high implying that the models are mis-specified. According to our results, all of the F-values in the linear model are insignificant, whereas, in the log-linear and log-log models, all of the F-values are highly significant. Therefore it appears that the linear model is the only one that is not mis-specified

The modified J-test was also used to help chose between the models. The J-test is a test of a non-nested hypothesis. Its calculation involves two steps. First, each model is estimated and their respective predictions are stored. Then, each predicted value is included as an explanatory variable in the competing model (Coelli et al. 1991). Three conclusions can be drawn. First, if the t-ratios of the included predicted values are both significant or insignificant, then neither model is preferred to the other. Second, if the predictions of model 1 are significant in model 2 but model 2's predictions are insignificant in model 1, then model

Table 5.2
OLS Estimates of Three Alternative Functional Forms*

Linear		Log-Linear		Log-Log	
Depn var = price		Depn var = Log (price)		Depn var = Log(price)	
WATER	178.30 (3.513)	WATER	0.26862 (3.269)	WATER	0.27466 (3.388)
BUILD	0.9573E-02 (10.82)	BUILD	0.9758E-05 (6.811)	BUILD	0.9792E-05 (6.833)
AREA	-5.1906 (-2.488)	AREA	-0.811E-02 (-2.402)	LOG (AREA)	-0.812E-02 (-2.404)
PASTURE	0.38672 (0.4247)	PASTURE	-0.968E-03 (-0.6563)	PASTURE	-0.94E-03 (-0.6373)
DBR	14.309 (0.1175)	DBR	-0.924E-01 (-0.4686)	DBR	-0.737E-01 (-0.3639)
TB	97.952 (0.4072)	TB	-0.176E-01 (-0.45E-01)	TB	-0.41E-02 (-0.12E-01)
SOILDEPT	26.863 (1.606)	SOILDEPT	0.1965E-01 (0.7262)	LOG(SOIL DEPT)	0.7643E-01 (0.5904)
WTB	-35.105 (-0.1244)	WTB	0.8433E-01 (0.1846)	WTB	0.7648E-01 (0.1674)
STONES	64.281 (1.221)	STONES	0.6927E-01 (0.8130)	STONES	0.6605E-01 (0.7709)
CANAL	-39.199 (-0.7055)	CANAL	-0.353E-01 (-0.3923)	CANAL	-0.378E-01 (-0.4204)
DIST	-0.669E-01 (-0.49E-01)	DIST	0.201E-03 (0.912E-01)	DIST	0.158E-03 (0.712E-01
DISTRD	-0.896E-01 (-0.26E-01)	DISTRD	-0.653E-03 (-0.1165)	DISTRD	-0.435E-03 (-0.78E-01)
VLC	182.37 (1.52)	VLC	0.4486 (2.31)	VLC	0.459 (2.362)
LC	309.56 (3.299)	LC	0.5864 (3.86)	LC	0.5853 (3.846)

Table 5.2
OLS Estimates for Three Alternative Functional Forms (Continued)

Linear **Depn var =price**		**Log-Linear** **Depn var = Log(price)**		**Log-Log** **Depn var= Log(price)**	
MC	42.007	MC	0.25761	MC	0.25762
	(0.3387)		(1.283)		(1.28)
LT	155.91	LT	0.36241	LT	0.35972
	(1.745)		(2.506)		(2.48)
AT	64.825	AT	0.15998	AT	0.16284
	(0.7959)		(1.213)		(1.234)
HOUSE	-29.051	HOUSE	0.2045E-01	HOUSE	0.1997E-01
	(-0.64)		(0.2782)		(0.2715)
RAIN	-1.0788	RAIN	-0.228E-03	LOG	-0.122
	(-0.451)		(-0.59E-01)	(RAIN)	(-0.93E-01)
CONS	1346.2	CONS	7.0711	CONS	7.6716
	(1.710)		(5.548)		(1.023)
R^2	0.5547		0.4541		0.4536
Ramsey Reset Test using powers (2, 3 and 4) of the predictions:					
F(1,209)	0.18050		8.1135		8.3232
F(2,208)	1.1472		4.0506		4.1702
F(3,207)	2.4091		2.7982		2.8563

*T-ratios are in parentheses.

1 is preferred to model 2. Third, if model 2's predictions are significant in model 1 and model 1's predictions are significant in model 2, then two is preferred. The t-ratios relevant to this test are presented in Table 5.3. It can be seen from Table 5.3 that the linear model is superior to both the log-linear and log-log model at the 5 percent level of significance. These results are in agreement with the results of the Ramsey Reset test presented in Table 5.2.

Given the cross-sectional nature of the data, it is possible that heteroscedasticity may be prevalent in the models considered. The SHAZAM package of White et al. (1990) provides a general test for this. The results of this test indicate that none of the calculated statistics in any of the models indicated significant heteroscedasticity. Thus none of the models had to be corrected for heteroscedasticity.

Table 5.3
T-Ratios for the J-Test for Functional Form

	Model into which Predictions are Included		
Model from which Predictions were Derived	linear	log-linear	log-log
linear	****	1.833	1.899
log-linear	0.00935	****	0.1509
log-log	0.1078	0.5547	****

5.3 Results and Discussion

As mentioned earlier, the results of the linear model are presented in Table 5.2. The model makes use of both dichotomous and continuous variables. The dichotomous variables represent shifts in the hedonic price function; therefore, the coefficients of these variables can be interpreted as the direct impact of these attributes on farm values. The continuous or quantitative variables have defined partial derivatives and the coefficient value of these variables are the marginal implicit price of the attribute.

The dichotomous variables in our model include WATER, DBR, TB, WTB, STONES, CANAL, VLC, LC, LT, AT, and HOUSE. The variable that is of most interest to this analysis is WATER . The coefficient value of WATER is 178.30 and is significant. This means that if a farm has access to irrigation water the value of the farm will increase by

$178.30 an acre. The three soil types in our study area (brown, dark brown and thin black) were all specified as dummy variables with brown soil being the base case. Results of our model indicates that the coefficient values of dark brown soil (DBR) and thin black soil (TB) are 14.309 and 97.95 respectively. Since neither of these values is significant, this result indicates that there is no significant productivity difference between thin black, dark brown and brown soils in our sample. Therefore, these variables will be omitted from the final model. This result may seem surprising, however, a significant portion of our sample of farm land is irrigated. On irrigated farm land the soil type does not impact productivity as much since moisture is no longer a limitation on the soil.

The relationship between irrigation and different soil types is also measured in this model. Two variables were originally specified, WDBR and WTB. WDBR measures the relationship between dark brown soil and irrigation and WTB measures the relationship between thin black soil and irrigation. The base case to which both of these variables will be compared is the instance of brown soil and irrigation. As noted earlier, WDBR was dropped from this model because of its strong collinearity with WATER. WTB remained in the model. The results indicate that there is no significant productivity difference between irrigated thin black soil and irrigated brown and dark brown soil. These results appear to confirm, once again, that the soil type may not significantly impact the value of land that is already irrigated.

The coefficient value on STONES appears to indicate that stones located in the soil profile of the farm land do not significantly impact the land values. Farms that have a significant degree of stones on them are expected to be worth less than farms that are relatively stone free. The land plots included in our sample generally do not appear to have any significant problems with stones; therefore, this appears to be a reasonable result.

CANAL indicates that there is an irrigation canal located on or adjacent to the property. The presence of a canal on farm land is expected to decrease the value of a farm. There may be two reasons for this. First, if a canal runs through a land parcel the farmer may have to incur higher capital costs since machinery must now travel around the canal or make extra passes. Second, water seepage may be a problem, particularly in older canals. This seepage could cause water logging and higher salinity levels in soil immediately surrounding the canal. Our model indicates that canals located on farm land do not significantly decrease the value of the land. In recent years, many of the irrigation districts (especially the Western Irrigation District) have upgraded their delivery systems by replacing some canals and by improving the lining on others. Also, many of the canals on the farm lands run adjacent to or along the edge of the farm so that their location does not disrupt the cultivation pattern of the farmer. Thus, the result of CANAL seems reasonable.

The distance variables VLC, LC, MC, LT, and AT indicate whether the nearest market from the farm is a very large sized city (VLC), a large sized city (LC), a medium sized city (MC), a large sized town (LT), or an average sized town (AT). Once again, all of these variables are dummy variables and the coefficient values of these variables will be interpreted with respect to the base case where the nearest market is a small town. In our sample VLC refers specifically to the city of Calgary, LC refers specifically to the city Lethbridge and MC refers specifically to the city of Medicine Hat. The other two terms, LT and AT, do not make reference to any specific town, rather they refer to a number of large and average sized towns located within our study area.

The results of the model indicate that if the nearest market to a farm site is the city of Calgary then that farm will be worth $182.37 more per acre than if the nearest market was a small town. The coefficient value of the LC variable indicates that if the nearest market to a farm site is the city of Lethbridge, that farm will be worth $309.56 more per acre than if the nearest market is a small town. The coefficient value of LT indicates that farms located close to large towns (such as Strathmore, Taber, etc.) are worth $155.91 more per acre than farms located closer to small towns. The other variables, MC and AT, indicate that if the nearest market is the city of Medicine Hat or an average sized town, then farm land values will not be worth significantly more per acre than if the nearest market is a small town. The significant values of VLC and LC were expected. Farm lands that fall within the urban shadow of these cities can enjoy a wider range of services and amenities than farms that are located next to small towns. This may also be true, to a lesser extent, for farms located next to large towns (LT). The value of LC implies that Lethbridge has a greater impact of farm land values than the larger city of Calgary. This result could be also be an artifact of the data. Most of the farm land that had Lethbridge as their nearest market were located in the county of Lethbridge and fell more directly under the direct urban shadow of Lethbridge. However, as explained earlier, land parcels that had Calgary as the nearest market were actually located in Wheatland which is the neighbouring county to Calgary. Therefore, Lethbridge had a more direct influence on the farm land in its market range than did Calgary in this.

The variable HOME indicates whether the farmer's home is located on the land or not. The coefficient value on this variable indicates that if a farmer's home is located on a farm, it will not significantly impact the value of the farm. It was expected that HOME would significantly impact the value of farm land. However, many land purchasers may not want any houses on the property they buy particularly if they already have a house on their other land holdings and they are using the additional land strictly for cultivation or other purposes. Also, HOME is strongly collinear with BUILD and this collinearity may be affecting the coefficient values of this variable.

The remaining variables, BUILD, AREA, PASTURE, SOILDEPT, DIST and RAIN, are all continuous variables. BUILD is the most highly significant variable in our model. This variable measures the contributory value of buildings to land prices. The results show that one dollar spent on upgrading or adding improvements to the land will increase the value of the farm by one cent per acre. The area of the land (AREA) also significantly impacts its value. The results of the model indicate that if we add one more acre of land to our land parcels, it will decrease the value of the land by $5.19 per acre. Earlier it was noted that we expected this relationship because smaller farms are usually more productive and because more people are able to afford smaller parcels, therefore their price per acre is bid up (Coelli et al, 1991). PASTURE does not appear to affect the value of land. This result seems reasonable since most farm areas located within our sample do not have large pasture areas. SOILDEPT refers to the depth of the soil in inches. Soil depth can range anywhere from 4 to 9 inches on the top soil. An additional inch of soil adds $26.84 per acre to the value of the land according to our analysis. DIST refers to the distance of the land parcel to the nearest market. The relationship here is expected to be negative since farms that are located further away from the respective markets are worth less. However, our results indicate that farm land values are not significantly affected by distance to market. Accessibility to markets is generally good in southern Alberta, so it is not surprising that DIST is not significant. Finally , it was noted above that RAIN was not expected to be a significant variable because the study area is relatively small and it receives approximately a uniform amount of rainfall. The direction of RAIN is negative indicating that another mm of rain will decrease the value of farm land. However, as suspected, the coefficient on RAIN is not statistically significant, therefore, no weight will be attached to this result.

A large number of the variables mentioned above have coefficients with t-ratios that are insignificant. The model was re-estimated with these variables omitted. This involved deleting PASTURE, DBR, TB, SOILDEPT, WTB, STONES, CANAL, DIST, DISTRD, MC, LT, AT, RAIN and HOME from the model. The lack of significance of these variables could be due to the relative unimportance of these factors in determining land values or the approximate way in which the information was defined, or a combination of these.

The restricted model is presented in Table 5.4. The joint test of the fourteen restrictions (variables that were omitted) yields an insignificant F-value of 0.53 indicating that these variables did not add significantly to the explanatory power of the model. Therefore the restricted model is preferred.

The interpretation of the coefficients of the remaining variables in the restricted model is as outlined above. The coefficient value of WATER is 189.98. That is, farms that have access to irrigation are worth $190 per acre more than farms that do not have access to irrigation. In our earlier model, the value of having access to irrigation water is approximately $178.30 per acre. Since the restricted model is the preferred one, the estimates of WATER in this model will be the preferred estimate.

Table 5.4
OLS Estimates of the Preferred Linear Model

VARIABLE	COEFFICIENT VALUE	T-RATIO
WATER	189.98	5.007
BUILD	0.93130E-02	12.08
AREA	-5.1751	-2.728
VLC	122.61	2.390
LC	216.09	4.734
CONSTANT	1226.7	4.073
R-SQUARED	0.5390	

The coefficient value of BUILD implies that for every dollar spent on farm buildings and improvements, the value of land will increase by 1 cent per acre. The coefficient value on AREA is -5.1751. This means that if we incorporate an additional acre of land into production, the value of the land will decrease by $5.17 per acre. This results were expected based on the premise that in more productive areas, farms tend to be smaller since less land is needed to meet production levels. Also, land parcels located closer to urban areas tend to be smaller in size and worth more per acre. These two influences may be contributing to the negative relationship between PRICE and AREA. The coefficient value on VLC is $122.61 implying that farm land that is near Calgary is $122.67 per acre more than farm land that is near a small town. Finally, the coefficient value of LC indicates that farms located near Lethbridge are worth $216.09 more than farms located near small towns. Lethbridge appears to influence land values more than Calgary, however, this may only be an artifact of the data set collected. In our sample, farms that have Calgary as the nearest market are located in the adjacent county to Calgary. The farms that have Lethbridge as the nearest market are located within the same county as Lethbridge and may fall more directly under the urban shadow of Lethbridge than farms that have Calgary as the nearest market in our data set.

5.4 Test for Market Segmentation

Earlier it was hypothesized that the same hedonic price function may not apply across the entire study area.[12] This may be due to inherent differences in soil types, water scarcity or other factors which may cause farming practices to differ from one area to another.

To test for market segmentation, the data was divided into two groups. In one group, we included counties that did not receive a significant portion of irrigation. In this group we included the counties of Wheatland, Forty Mile, Vulcan and Warner. In all of these counties, less than 50% of the land parcels sold were using irrigation water.[13] In the other group, we included the remaining counties (Lethbridge, Newell, Taber and Cypress) in which over 50% of the land parcels sold were using irrigation.

The nature of our data makes it difficult to test for market segmentation. Smaller sub-sets of our sample do not have enough variability between bare land values and irrigated land values to produce reasonable estimates of water right values. Early attempts were made to re-estimate the preferred model using data from each of the groups indicated above (Coelli *et al.*, 1991); however, this did not provide any conclusive results. Careful re-specification of the model had to used to determine the value of water rights in our two groups.

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[12] See the section on market segmentation in Chapter Two.

[13] This percentage was arbitrarily chosen.

The details of how the new model was re-specified are given below. The explanatory variables WATER, BUILD, AREA and LC are the same as before in the preferred model. Only one variable, WHEAVY, was added to our model. WHEAVY is an interactive (slope) dummy variable specified in the following manner:

WHEAVY = land that is irrigated and is located in a county where over 50% of the land sold was using irrigation (1=yes, 0=otherwise).

WHEAVY by itself is not really a measure of market segmentation. Rather, it is an interaction term that measures the relationship between sale prices of irrigated land located in areas using more irrigation and irrigated land located in areas using less irrigation. This relationship may give us an indication of different implicit values of irrigation water for different areas within our sample.

Another dummy variable was also initially included in the model. This dummy variable reflected whether the land sale occurred in a heavily irrigated district or not. This variable was designed to capture the impact of unobserved variables in each area (such as the impact of local farm management techniques, micro-markets and other factors) on land prices. Initial results indicated that this variable was insignificant, therefore this variable was omitted from the revised model. The results of the newly specified model are provided in Table 5.5.

The coefficient value on WATER should be interpreted as the implicit value of water rights in the lightly irrigated counties. The results indicate that in counties where land is irrigated relatively lightly the implicit value of having access to irrigation is $151 per acre. A t-test of the coefficient value for WATER indicates that it is significant. The interpretation of the coefficient values for the variables BUILD, AREA, VLC and LC remain the same as before. BUILD indicates the marginal implicit value of buildings for our sample as a whole,

Table 5.5
Results of Test for Market Segmentation

Variable	Coefficient Value	T-Ratio
WATER (WLIGHT) (n=134)	150.88	2.594
WHEAVY (n=96)	56.573	0.8869*
BUILD	0.0092717	12.00
AREA	-5.0820	-2.674
VLC	125.81	2.445
LC	203.50	4.256
R^2	0.54	

*indicates that the value is not significantly different than zero. The critical value in this case is 1.658.

AREA refers to the marginal implicit value of an additional acre of land and VLC and LC indicate the impact of the nearest market being a very large city (Calgary) or a large city (Lethbridge), respectively.

The variable that is of interest in this model is WHEAVY. The coefficient value of WHEAVY is 56.573. This means that the implicit value of having access to irrigation water is $56.57 more than in lightly irrigated counties. However, an examination of the t-statistic indicates that the implicit value of irrigation water in the heavily irrigated areas is not significantly different from that in the lightly irrigated areas. Thus, it may be reasonable to conclude that there is no difference between the implicit value of irrigation water in lightly and heavily irrigated counties. This may lead us to imply that market segmentation is not a significant factor within our sample.

This result was somewhat of a surprise. It was expected that the implicit value of irrigation water would be significantly higher in heavily irrigated areas than the lightly irrigated areas. In the heavily irrigated areas, a higher proportion of irrigated acreage is devoted to specialty crops (27% in the county of Taber and 19% in the county of Cypress)[14] than in any of the other counties in our sample (Alberta Agriculture, 1994). Specialty crops include such crops as sugar beets, potatoes, peas, corn, beans and other crops. These crops are considered a higher valued use of irrigation water because the return on them is relatively high.. In 1994, the county of Taber had a higher average return ($121.95 per acre) on its irrigated crops than any other county in our sample (Alberta Agriculture, 1994).

The results of model may not be as much of a mystery if we consider some of the other market influences occurring at the time. The price of cattle, for instance, has been rising steadily since 1984 and in 1993 cattle prices were at their all time high (Alberta Agriculture 1993). The rising price of cattle may have increased the use of irrigation water in relatively low valued uses such as pasture irrigation. This may have been particularly true in the counties of Lethbridge and Newell which traditionally support a heavy concentration of feed lot operations (Alberta Agriculture 1993). Another factor that may have been influencing our results is the price of specialty crops. As mentioned earlier in Chapter four, the price of specialty crops such as corn for grain, dry peas and potatoes were declining at this time.

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[14] Twenty four observations were taken from the county of Taber and 8 were taken from the county of Cypress.

These trends may have lowered the demand for land in areas that traditionally grow a higher proportion of specialty crops such as Taber.

5.5 Summary

In the preceding analysis, the hedonic price equation, specified in Chapter 4, was estimated and the results analysed. The theoretical nature of the hedonic price model dictates that a number of issues must be dealt with when applying this technique. The first is the issue of model specification. There are very few limits to the number of variables that can be included in a hedonic equation. The real question then becomes: which variables can be taken out of the hedonic model without significantly affecting the overall predictability of the equation? In this chapter, three unrestricted models which included nineteen different variables were originally estimated. Once the preferred model was chosen, fourteen of the variables were eliminated through trial and error and only five variables remained in the model. A joint F-test of the fourteen variables eliminated produced an insignificant value indicating that the predictability of the model was not affected by reducing the number of explanatory variables in the model.

The second issue is the one of functional form. Three functional forms including the linear, the log-linear and the log-log functional forms, were estimated. The Ramsey Reset test and the modified J-test were both used to determine that the linear model was the best fitting functional form. Halvorsen and Pollawkowski (1981) have suggested using the more flexible quadratic Box Cox functional form. This is a flexible functional form which embodies many of the popular functional forms, such as the linear, log-linear and log-log functional forms, as special cases. Graves et al (1988) and Cropper, Deck and McConnell (1988) have demonstrated that the predicted values of attributes are very sensitive to changes in the regressor set if the quadratic Box-Cox functional form is used. The danger of obtaining poor estimates of the implicit value of water rights due to variable omission or mis-specification led us to only consider the linear, log-linear and log-log forms.

A third issue is the one of market segmentation. The preferred model (results seen in Table 5.4) was re-specified to test for the existence of market segmentation. The results (Table 5.5) indicate that no market segmentation exists within our sample. However, this result may only be a reflection of market forces that were occurring at the time. If a longer time period were considered, there may be some market segmentation noted between lightly irrigated counties and heavily irrigated counties that have a higher proportion of irrigated crops devoted to specialty crops.

CHAPTER 6

CONCLUSIONS

The hedonic model may be a useful tool in determining the value of water rights. The advantage of this technique is that it estimates the value that farmers express for irrigation water in the market place for land. Such values can give us an indication of the anticipated prices which might prevail in a transferable water rights market in southern Alberta.

In the foregoing analysis, the mean value of having access to irrigation water has been provided. This was done by estimating the hedonic price function for the south eastern region of Alberta. The hedonic price function represents an interaction of what buyers are willing to pay and sellers are willing to accept in the market place for access to irrigation.

In Chapter 5, the results of the preferred model (Table 5.4) indicates that the implicit value of having access to irrigation water in southern Alberta is approximately $190 per acre or $190 per acre. Since this values represents the implicit amount farmers are willing to pay for access to water, they could also be construed as an indirect measure of the value of water rights. This value was estimated by first specifying a hedonic model with land prices as a function of a number of factors which may influence land prices (such as presence of irrigation on the land, the size of farm, the value of buildings on land, the proximity of land to major cities and so forth). Once the model was estimated, the coefficient values of the variables included in the model represented the marginal impact of each of these characteristics on land prices holding all other things constant. Therefore, in the hedonic model , the value of water rights represented the average difference between land values of farms that have access to irrigation and farms that do not, *ceteris paribus*.

An important issue in this application of the hedonic technique is the question of market segmentation. Differences in soil characteristics, crop mixes and irrigation districts may cause farmers in various regions to have different utility functions for water rights. Market segmentation was tested for in Chapter 5 by re-specifying the preferred model seen in Table 5.4. The re-specified model in Table 5.5 indicates that market segmentation is not a factor within our sample. However, this result may only be a reflection of the market influences occurring at the time of the observations. The high price for cattle combined with the falling prices of various wheats, grains and specialty crops, may have caused the demand for irrigation water to shift away from higher valued uses of this resource to lower valued uses such as pasture irrigation. This shift in demand may have eliminated the expected market segmentation between areas demanding water for high valued uses and areas demanding water for low valued uses. Land sales data collected over a longer time series may demonstrate a greater affinity for market segmentation

Finally, an examination of the data reveals that the values of water rights estimated in the preceding analysis add approximately 35% to the value of non-irrigated land. This may not represent a dramatic increase in the value of non-irrigated land, however, it may be reasonable to a conclude that water rights do have a measurable impact on land values. Therefore, this resource can no longer be treated as a relatively free or cheap good. Proper incentives may be needed to ensure that water is used in the most efficient possible manner. A system of transferable water rights (see Chapter One) has been suggested as a means of doing this. However, before policy makers can accurately assess the economic merits and costs of such a system more information is needed on the value of water rights. In the preceding analysis, this information has been provided. The next step, which involves an economic assessment of a system of transferable water rights, is beyond the scope of this study.

6.1 Limitations of Study

There are a number of limitations affecting the results of this research. As with many hedonic studies Oczkowski (1994), Coelli *et al.* (1991), Crouter (1987), Dunford, Marti and Mittlehammer (1985), the data used for this study originated from a secondary source. In cases such as this, the original information is not collected for the purposes of a hedonic analysis. Many unobserved factors such as the reason for the land purchase, the intended use of the land (types of crops that will be grown on it) and other factors influencing the value of land prices are not accounted for. A primary data collection in which each of the land buyers and sellers are interviewed may provide the researcher with a better understanding of all the factors affecting the land values. The use of primary data could also give us a better idea of the number of idle water rights in southern Alberta. If a transferable water rights markets is ever to be adopted, it is assumed that these would be the first rights available for sale on the open market.

A second concern involves the specification of soil quality. The soil zone, which was the variable eventually used in our model , only accounts for part of the overall soil quality. Time and funding restrictions precluded us from adapting existing soil quality scales to ones with economic interpretation. As a result, the impacts of soil quality had to be largely precluded from our model even though it was believed that it may be significant. It may have proved instructive to create a scale which provides a better economic measure of soil quality.

A third concern pertains to the underlying assumption of the functional form in our model. Ramsey Reset tests and modified J-tests were used to determine that the linear functional form is the best fitting functional form for our data. A linear hedonic model assumes that the marginal implicit value of water rights is constant regardless of the supply levels of water. This may be a heroic assumption in Alberta's case, especially since times of drought are likely to impact farmers in counties such as Lethbridge and Newell more than the other counties in our sample.

Finally, when testing for market segmentation, the results of our model may only reflect a snap shot in time. The data set, on which the hedonic model in this study was based, was taken from land sales occurring in 1993 and the first part of 1994. High beef prices appear to be the dominant influence on water rights values during this time. However, this may not have always been the case. Therefore, a hedonic model based on a longer time series of data may have provided a better indication of which counties have a higher demand for irrigation water.

6.2 Suggestions for Further Research

The purpose of this study was to determine the value of water rights in southern Alberta. This information is meant to provide a background framework for assessing the benefits of a system of transferable water rights. Therefore, future studies that assess the relative merits and shortcomings of the proposed system are needed to complement the research done here.

To perform studies such as these, a primary survey of a representative group of irrigation farmers is likely to be needed to gain recent data on the residual value of water in alternative uses. These values can be matched against the potential costs of transferring water from one area to another. Other key policy problems will also have to be dealt with in this context such as: (1) How will the water initially be allocated? (Prior use or auction?) (2) How will the governments deal with the arising complications of water rights that are currently assigned to irrigation districts. (3) Should the sale of rights be temporary or permanent? (4) Should the transfer of rights be limited to within basins or sub-basins or should transfers be permitted outside the basin (for example, from the Bow River to the Old Man River)? (5) Should the transfer of water rights occur within a sector (such as agriculture) or across sectors (from agriculture to higher valued municipal use). (6) How prevalent should the role of third party effects and in stream flow needs be in determining where and how the water is allocated?

All of these questions still remain to be answered. Future research in this area can help to determine if a system of transferable water rights is the correct policy mechanism for Alberta.

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APPENDIX A

RATING OF DIFFERENT LAND CHARACTERISTICS

A.1 Introduction

The hedonic model specified in the preceding analysis includes many of the variables considered by land assessors as important in determining the value of farm land. In this section, the methodology that land assessors use to determine the assessed value of land parcels is described. This section begins by reviewing how each of the physical land characteristics such as the soil group, the soil depth, the soil texture, the topography of the land, the degree of stoniness of the land and the locational characteristics of the land are given a rating factor. The section then concludes with a description of how these rating factors are converted into a dollar value for assessment purposes.

A.11 Soil Groups

Soils are classified on the basis of observable physical characteristics in the soil profile. (i.e. a section downward through the upper two to four feet of the soil). The factors chiefly responsible for the formation of the soil profile are climate and vegetation (Alberta Municipal Affairs 1979).

Climate is possibly the most influential factor of soil profile. Climate influences the kind, number and activity of soil organisms important to the soil building process. It determines, in combination with texture, how quickly fine particles are removed from the surface of the soil. Temperature and rainfall in a certain climatic zone may also indirectly determine the type of vegetation native to a certain region.

The native vegetation largely determines the colour of the surface horizon. The colour of the soil in the upper portion of the soil is a result of decomposed vegetative residue. The greater the accumulation of the decomposed organic matter the darker is the colour of the soil. Thus the relatively dry climate and short grass prairie in the south have produced brown soils whereas moister climates and taller grasses in the central portions of the province have produced black soils. (Alberta Municipal Affairs 1979) These two factors, climate and vegetation, acting together over a long period of time, have produced the soil zones (or soil groups) in Alberta which include the Brown, Dark Brown, Thin Black, Black , Dark Gray and Gray Wooded soil groups.

In our study area, there are only three different soil groups. These include the Thin Black, Dark Brown and Brown soils. The Brown soils occur primarily in the semi-arid short grass prairie region of the province. The average annual precipitation in these areas is about 30 cm. The Dark Brown Soils are found in areas slightly less arid than the Brown Soil area where the average annual precipitation is approximately 35 cm. The Thin Black soils occur in areas with dry to sub-humid conditions with an average annual rainfall of 38-45 cm. Table A.1 (Alberta Municipal Affairs 1979) summarizes how soil groups and soil depth are rated.

The soil group receives an automatic rating based on average yields of the common crops grown across the province. The soil thickness ratings are based on the thickness of the top layer of soil. In the case of Brown, Dark Brown and Thin Black soils this is usually the Ah or accumulated humus layer of the soil (i.e. the horizon layer in which humus accumulated).

Table A.1 (Alberta Municipal Affairs 1979)
Rating Factors for Soil Group and Soil Depth

Soil Group	Rating	Surface Depth	Rating
Thin Black	0.85	13cm (5") Ah(Bk)/D.BR	1.00
		10cm (4") Ah(Bk)/D.Br	0.95
		8cm (3") Ah(Bk)/D.Br	0.90
		5cm (2") Ah (Bk)/D.Br	0.85
Dark Brown	0.70	3-5cm (1-2") Ah(Bk)/D.Br)	1.00
		0-3cm (0-1") Ah(Bk)/D.Br)	0.95
		15-18cm (6-7") Ah(D.Br)	0.90
		13-15cm (5-6") Ah(D.Br)	0.85
		10-13cm (4-5") Ah(D.Br)/Br	0.80
		8-10cm (3-4") Ah(D.Br)/Br.	0.75
		5-8cm (2-3") Ah(D.Br)/Br.	0.70
Brown	0.45	13cm (5") Ah(Br)	1.00
		10-13cm (4-5") Ah(Br)	0.90
		10cm (4") Ah(Br)	0.80
		8-10cm (3-4") Ah (Br)	0.70
		8cm (3") Ah(Br)	0.65
		5cm (2") Ah(Br)	0.60

*Ah or Accumulated humus refers to the upper layer of soil in the soil profile. Soils that had an additional layer of soil with a dark brown and black soil mixture (AH (Bk)/DBr) were considered more valuable. Therefore, dark brown soil receives a maximum 0.9 rating if it is 18cm in depth. It receives higher ratings (0.95 or 1.00) if there is an additional layer of black and dark brown soil on top of this.

A.12 Soil Texture

Soil texture refers to the relative proportions of sand, silt and clay particles in the soil mass. The texture of the soil is closely related to other soil properties such as its ability to hold moisture, its power of cohesion, its ease of cultivation etc. For assessment purposes soil textures are classified as gravel, sand, silt , clay or, more commonly , as a combination of these such as loam , clay loam, sandy loam and silt loam. Under irrigation soil texture is not rated so much on its ability to hold moisture as its ability to absorb water quickly and its facility to permit downward movement of the water. For this reason the moderately coarse and medium textures are more desirable than the fine textures. This discrepancy in soil texture ratings between irrigated and non-irrigated land has made it difficult to compare soil texture ratings from irrigated land with soil texture ratings from non-irrigated land. Table A.2 summarizes the rating of soil texture on irrigated land plots.

A.13 Topography

Topography can influence crop production by (1) reducing yield and (2) increasing operating costs. Yields can be reduced if the land topography is rough or hilly. The tops of hills are generally drier than the remainder of the field since moisture runs off the hills. Also, water tends to accumulate in low lying areas, delaying seeding and causing uneven ripening in the field. Quite often these low areas, in fairly rough topography, are subject to late spring and early fall frosts. Rough topography can also increase operating costs. Sloughs or low wet areas may require more turns and overlapping of work by the farm machinery. Often special cultural practices must be followed on rough topography to reduce soil erosion by water.

Eight classes of topography are recognized by land assessors. These include Flat to depressional, level or gently sloping, undulating, gently rolling, rolling, strongly rolling to hilly and humpy. Like soil texture, topography ratings depend on whether the land is being irrigated or not. Topography is one of the most obvious physical features affecting the application of irrigation water with respect to erosion and ponding. Therefore, rough topography will deduct more from the value of the land if it is irrigated than if it is not.

Table A.2 (Alberta Municipal Affairs 1979)
Irrigated Land Soil Texture Rating

Texture Description	Rating Factor
Silt Loam (SiL)	1.00
Heavy Silt Loam (HvSiL)	0.90
Silty Clay Loam (SiCL)	0.80
Heavy Silty Clay Loam (HvSiCL)	0.70
Loam (L)	1.00
Heavy Loam (HvL)	0.90
Clay Loam (CL)	0.80
Sand Clay Loam (SCL)	0.80
Heavy Clay Loam (HvCL)	0.70
Clay (C)	0.50
Heavy Clay (HvC)	0.40
Very Fine Sandy Loam (VFSL)	1.00
Fine Sandy Loam (FSL)	0.90
Sandy Loam (SL)	0.70
Coarse Sandy Loam (CSL)	0.60
Loamy Sand (LS)	0.50

Loamy Sand - Sand (LS-S)	0.40
Sand (S)	0.30

Table A.3 (Alberta Municipal Affairs 1979)
Topography Rating for Non-Irrigated Land

Topography Description	Rating Factor
Flat to Depressional (F-D)	0.50-0.90
Level or gently sloping or gently undulating (L-GS, GU)	1.00
Undulating (U)	0.95
Gently Rolling (GR)	0.85-0.90
Rolling (R)	0.80-0.85
Strongly rolling - Hilly (STR-H)	0.70-0.75
Hilly (H)	0.65
Very Hilly (VH)	0.50

Table A.4(Alberta Municipal Affairs 1979)
Topography Rating for Irrigated Land

Topography Description	Factor Rating
Level or Very Gently Sloping (L-VGS)	1.00
Very Gently Undulating to Very Gently Sloping (VGU-VGU)	0.90-0.95
Gently Undulating (GU)	0.75
Gently Undulating to Undulating	0.70
Undulating (U)	0.65
Undulating to Roughly undulating (U-RU)	0.60
Roughly Undulating (RU)	0.55
Very Roughly Undulating (VRU)	0.50
Flat or Depressional rating depends on feasibility of drainage	0.20-0.50

Gently rolling irregular or moderately sloping	0.20-0.50
Rolling hilly or steeply sloping	0.15-0.35

Without any common scale to compare the topographical ratings of irrigated and non-irrigated soil this characteristic also had to be omitted from the model. The topographical rating factors for irrigated and non-irrigated land are seen below in Table A.3 and A.4 (Alberta Municipal Affairs 1979).

A.14 Stones

The presence of stones can effect yield but the chief concern is the effect on operating costs resulting from tillage difficulties, damage to machinery, cost of removal etc. Generally, wherever stones are found they occur throughout the soil profile, however, in certain areas they are strictly a surface phenomenon. In the latter case, the task of removing stones is a rather minor one since the land will be relatively stone free once the surface stones have been removed. If the stones occur throughout the soil profile, then they will be continually forced up to the surface by natural causes or dragged up by machinery. In this case, stone removal will become a regular task. These factors are considered by land assessors when they determine the rating for stones.

Four classes of stones are considered in setting up a rating schedule (Assessment Manual , 1979):

No stones: So

Occasional stones to moderately Stoney:

S1 slight to moderate handicap

S2 serious handicap

moderately stony to very stony:

S3 very serious handicap

S4 unsuitable for cultivation

The quality of the land will also determine the influence of stones on the value of the land. From an economic stand point, the influence of stones on the value of the land will increase as the quality and productive capacity of the land decreases. Therefore, severe stoniness will have a more noticeable impact on land with brown soil than land with black soil. The rating system of the land assessors has been established on this basis and is seen in Table A.5.

Table A.5 (Alberta Municipal Affairs 1979)
Stone Rating

	Soil Group and Rating Factor		
Stone Description	Thin Black	Dark Brown	Brown
S0	1.00	1.00	1.00
S1	0.90-1.00	0.85-1.00	0.85-1.00
S2	0.75-0.90	0.70-0.85	0.65-0.85
S3	0.60-0.75	0.55-0.70	0.45-0.65
S4	0.40-0.60	0.35-0.55	0.25-0.45

A.15 Location

The ratings on the soil group, depth, texture, topography and stoniness indicate the potential productivity of the soil. The next step in the assessment process is to appraise the influence of other extrinsic factors on the value of the land parcel.

Location also has an effect on the value of a land parcel. Land parcels located closely to urban centres have better access to market (where crops may be sold), shopping, cultural, recreational and school facilities. Each city, town and village is classed according to its size and the relative advantage it provides to the rural population (according to marketing, shopping, cultural recreational and school facilities). The maximum rating factor for different urban sizes is provided in Table A.6. Deviations from this schedule may be made at the assessor's discretion if conditions in a certain urban centre seem to warrant it. However, land assessors are encouraged to adhere to this schedule as closely as possible to maintain a reasonable degree in uniformity throughout the province (Alberta Municipal Affairs 1979).

Table A.6(Alberta Municipal Affairs)
Urban Proximity Rating

Size of Nearest Market	Rating Factor
Very Large city	1.40
Large city	1.25-1.30
Medium city	1.20-1.25
Small city/Large town	1.15-1.20
Average town	1.10-1.15
Small town/Average village	1.05-1.12
Village	1.03-1.10

Land parcels are rated according to their proximity to different sized urban centres. This rating factor is then reduced by a factor of 0.01 for every mile that the land parcel is distant from the urban centre. For example, if a farm is located 5 miles form an average village, it would receive a location rating factor of 1.05-.05 = 1.00. Similarly, if a farm is located only two miles from a very large city, it would receive a location rating of 1.40-

0.02=1.38.

Some caution must be expressed at this point regarding the application of the location rating factor. First, the location rating is not meant to be applied to railway sidings where only elevator facilities are available, or small centres which do not provide most of the facilities and services found in an average town or village (Assessment Manual 1979). Second, In instances where farms are located between two market facilities, an average of the rating factors for the two points may be taken or the respective rating factors may be weighted in proportion to the relative marketing and shopping facilities offered at the two points. For example, if facilities are divided between a centre with a railway service and one without a railway but good shopping and some marketing facilities, the rating factors may be weighted such as to give three-quarters of the weight to the railway centre and one-quarter to the shopping centre (Alberta Municipal Affairs 1979). Finally, if a deep Coulee or river must be crossed or if a ferry must be used to reach the urban centre, the rating factor will be reduced by a further by 0.01 to 0.05 (Alberta Municiapl Affairs 1979).

A.16 Access and Road Proximity

Access to various classes of roads may also influence the value of farm land. The rating factor for this is seen in Table A.6 on the next page. The rating factor is reduced by a factor of 0.00 to 0.02 for each mile that land parcel is distant form a primary or secondary hard surface highway. The rating is reduced by 0.00 to 0.04 for every mile that a land parcel is distant from a gravel or improved road.

Table A.7 (Alberta Municipal Affairs 1979)
Access and Road Proximity Rating

Class of Road	Distance	Rating Factor
Primary hard surface highway	Abutting (parcels within first 0.8km)	1.06
	parcels within 2nd 0.8 Km	1.03
Secondary hard surface highway	Abutting (parcels within first 0.8km)	1.04
	parcels within second 0.8km	1.02
Provincial gravel and all improved roads	Abutting (parcels within first 0.8km)	1.00

A.2 Farm Land Assessment: The Final Rating

The soil, location and road proximity ratings are all recorded on farm land assessment forms or "field Sheets". These forms are designed to provide space for recording all relevant information and characteristics of the soil, respective ratings and computation of the assessment. In addition, space is provided for sketching physical details on the land such as pastures, severances, farm sites etc. An example of one of these assessment forms can be seen in Figure A.1.

A.17 Final Rating

Having determined a rating for each of the factors contributing to, or detracting from the productivity of a land parcel a Combined Productivity Rating is computed by multiplying all the applicable soil ratings together.

For example, (Albeerta Municipal Affairs 1979) in Figure A.1 we have a land parcel with a thin black soil group (maximum rating 0.85), 3 inches in depth (0.90), normal subsoil (1.00), loam texture (0.90), gently undulating topography (1.00), stones S1 (.95), no trees (1.00), and a miscellaneous factor (0.95). This has a Combined Productivity Rating of:

0.85 x 0.90 x 1.00 x 0.90 x 1.00 x 0.95 x 1.00 x 0.95 = 0.63

The Combined Productivity Rating is then applied to the farm land Basic Rate established for the province to determine the Productivity Value per acre of the land as below:.

Basic Rate, per acre $240.00 x Combined Productivity Rating 0.63 = $151.20 Productivity Value, per acre.

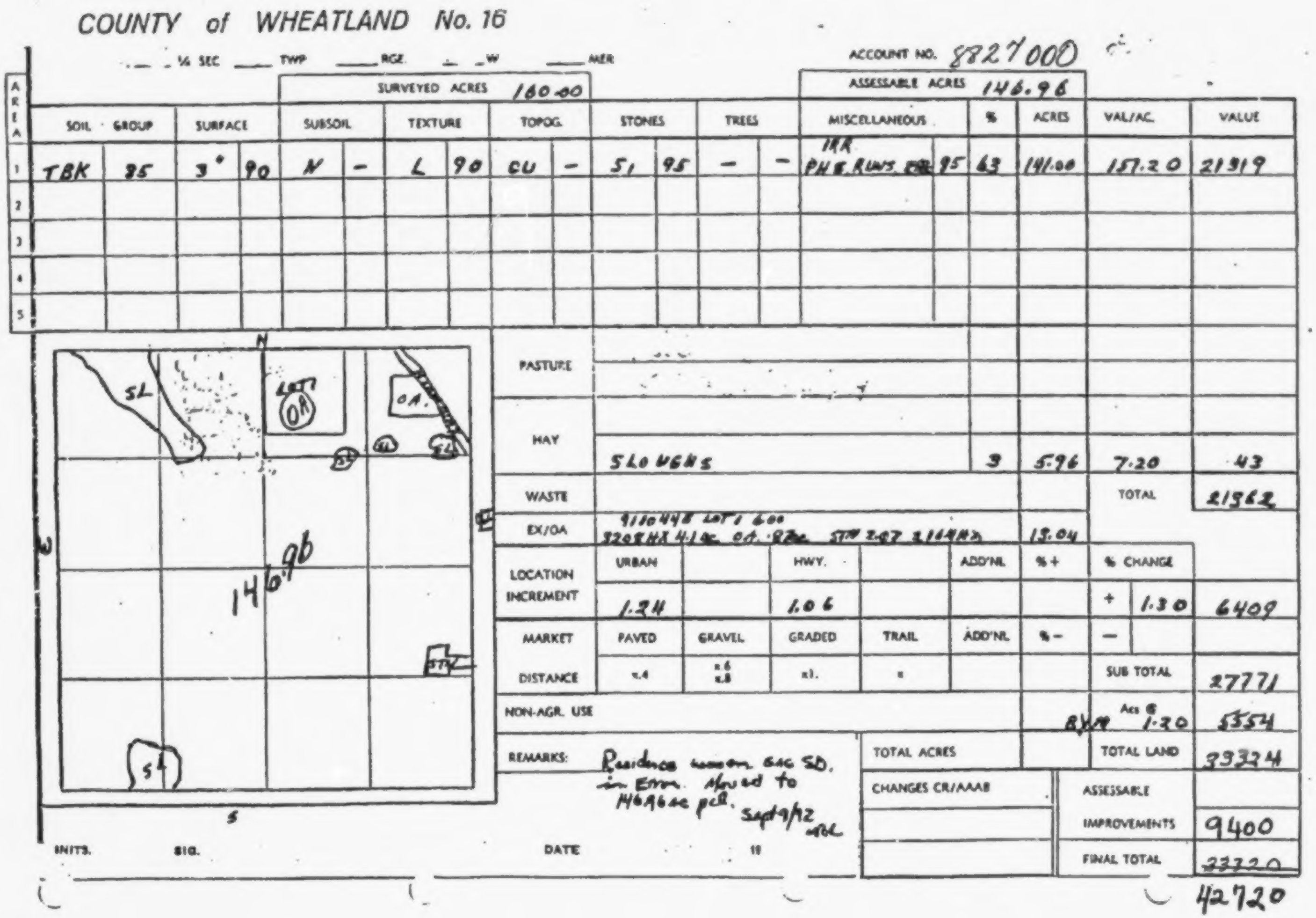
The number of farm land acres in the parcel are then multiplied by the Productivity Value per acre to determine the Total Productivity Value of the parcel. In our example:

$151.20 x 141.00 acres = $21 319 Total Productivity Value.

Some parcels may have different factors affecting various portions of the parcel. In cases such as this, more than one Combined Productivity Rating is required. Each of the subsequent ratings is then applied to the Basic Rate to determine the Productivity Value per acre for each portion which in turn is applied to the respective acreage involved. The sum of the various individual values then becomes the Total Productivity Value of the land.

The next step in the process involves the determination of a Combined Location Rating based on the location of the land with respect to urban centres and roads. In our

Figure A.1 County Assessor Field Sheet



COUNTY of WHEATLAND No. 16

___ ¼ SEC ___ TWP ___ RGE. ___ W ___ MER

ACCOUNT NO. 8827000

SURVEYED ACRES 160.00

ASSESSABLE ACRES 146.96

AREA	SOIL	GROUP	SURFACE		SUBSOIL		TEXTURE		TOPOG.		STONES		TREES		MISCELLANEOUS		%	ACRES	VAL/AC.	VALUE
1	TBK	85	3°	90	N	-	L	90	CU	-	5,	95	-	-	IRR PH E. RLWS.	95	63	141.00	157.20	21319
2																				
3																				
4																				
5																				

PASTURE					
HAY	SLOUGHS	3	5.96	7.20	43
WASTE				TOTAL	21362
EX/OA	9110448 LOT 1 6.00 9208HX 4.1ac O.A. .92ac STW 2.07 9164HX		13.04		

LOCATION INCREMENT	URBAN		HWY.		ADD'NL	% +	% CHANGE		
	1.24		1.06				+	1.30	6409
MARKET	PAVED	GRAVEL	GRADED	TRAIL	ADD'NL	% -	—		
DISTANCE	<.4	<.6 <.8	<1.	<			SUB TOTAL		27771
NON-AGR. USE							BXM Acs @ 1.20		5554
				TOTAL ACRES			TOTAL LAND		33324

REMARKS: Residence [illegible] 6AG SD. in Error. Moved to 146.96ac pcl. Sept 9/92

CHANGES CR/AAAB	ASSESSABLE	
	IMPROVEMENTS	9400
	FINAL TOTAL	~~33320~~ 42720

INITS. SIG. DATE 19

example:

Location(1.24) x Road Access and Proximity (primary hard surface highway - 1.06) = 1.30 Combined Location Rating.

The Combined Location Rating is multiplied by the Total Productivity Value to determine the 1977 Basic Value of the parcel.

T.P.V. $21 319 x 1.30 = $27771 1977 Basic Value

This value is then multiplied by the farm land Base Year Modifier for the year prior to the year of the general assessment. In our example, the base year modifier from the previous year is 1.02.

B.V. $27771 x 1.02 Base Year Modifier = $28 326 Total Land Value

The last step is to add the value of the assessable improvements to the total land value to determine the Fair Actual Value of the Land. Assessable improvements are the value of the farm house(s) on the land. In our example the Actual Fair Value is:

Total Land Value $28 326 + $9400 = $37 726 Actual Fair Actual.

This fair actual value represents the the total assessed value of the land parcel. It should be noted that the value of improvements only includes the value of improvements that are tax assessable. Therefore, these values are not reliable estimates of the total value of buildings and improvements on the land.

It should also be noted that the assessed value of the land was rarely equal to the actual price of the land. Market forces often result in land plots selling for significantly more than the assessed value and there was often very little relationship between the assessed value of the land and the actual sale value of the land.

A.3 Summary

The field sheets provided by the county land assessors provided us with valuable information about the soil characteristics, the appearance of the land and the value of taxable improvements on each land parcel. Some of this information was included in our hedonic model, however many of the scales used by the land assessors did not have any clear economic interpretation. In cases such as this, the information had to be adapted to new scales with clear economic interpretation or omitted out right.

APPENDIX B

SALES COMPARISON APPROACH

B.1 Introduction

This appendix reviews how the sales comparison approach was used to determine the contributory value of buildings to the price of the land in our sample. This method can best be described through example. Therefore , an example is provided below of how the sales comparison approach was used in this study.

B.2 The Sales Comparison Approach

The sales comparison approach involves a simple comparison of the values of a land parcel with buildings to a number of similar land parcels without buildings, in our sample, to estimate the amount that the buildings contributed to the price of the land. The general principal behind this approach is used by professional land appraisers to determine the contributory value of buildings to the price of the land. In our sample, this method was used for each observation involving buildings. An example of how this method was applied is provided below:

Assume a parcel of farm land was sold for a price of $120 000 dollars for a quarter section and the land had a number of buildings on it such as the farmer's house and a number of grain bins. The contributory value of those buildings was determined by comparing this land plot to a similar land plot with no buildings on it. The difference in the value of the land with buildings on it and the average value of similar land plots without buildings was considered to be an estimate of the contributory value of buildings to the sale price of the land.

The county assessor field sheets were used as a reference to determine the similarity of the land parcels being compared. The soil quality, texture, topography and stoniness were all compared to ensure that they were the same and received the same rating from the county land assessor. Another important consideration was the location. Land prices had to be compared to the prices of land in the immediate region to ensure that economic influences of local micro-markets were as similar as possible. Finally, land parcels with improvements were only compared to other land parcels that had been assessed as having the same or similar value (productive potential). These criteria were used to ensure that the land parcels being compared were as similar as possible to maximize the accuracy of estimating the influence of buildings on land prices. This procedure was followed for each land parcel in our sample that had improvements on it. The estimates of the contributory value of buildings to the price of the land was then included as an explanatory variable in our model.

B.3 Summary

Estimating the influence of explanatory variables on the price of land was a difficult task. As mentioned earlier in Chapter 4, the contributory value of buildings to the sale price of the land may be different in every case depending on how highly the buyer values the buildings on the land for his/her purposes. Therefore, estimating the influence of buildings on the value of the land *ceteris paribus* is extremely difficult without more specific information on each land sale. The sales comparison approach is a simple approach that gave us a reasonable estimate of the influence of the contributory value of buildings to sale values. A more accurate method would be to collect information on each seller and buyer involved in every sale. However, time and funding restrictions prevented us from doing this.

APPENDIX C

HEDONIC PRICE MODEL DATA

This appendix includes a listing of the data collected for this study. The column headings (or variables) on the following pages are defined below. A more detailed explanation of the specification of these variables is provided in Chapter Four.

OBS # - observation number

TPRICE - total sale price of land parcel

AREA - area of cultivated land (acres)

BUILD - estimated contributory value of buildings to the sale price of the land parcel

ASSPRICE - the assessed value of the land parcel as determined by the regional county/municipal district land assessor

RATIO - a ratio of the total sale price of the land (market value) to the assessed value of the land

PRICE - the per acre sale price of the land

PASTURE - area of land that is in pasture (acres)

RAIN - Average Annual rainfall (mm)

DBR - indicates that land has dark brown soil (1=yes, 0=no)

TB - indicates that land has thin black soil (1=yes, 0=no)

SOILDEPT - depth of top soil on land (inches)

WDBR - indicates that land is irrigated and has dark brown soil (1=yes, o=otherwise)

STONES - indicates the presence of stones on the land

VLC - nearest market is Calgary (1=yes, 0=otherwise)

LC - nearest market is Lethbridge (1=yes, 0=no)

MC - nearest market is Medicine Hat (1=yes, 0=otherwise)

LT - nearest market is a large town (1=yes, 0=no)

AT - nearest market is an averaged sized town

HOME - producer's home is located on the land parcel (1=yes, 0=no)

CANAL - direct access toirrigation canal (1=yes, 0=no)

HEAVY - land is located in an area where over 50% of the land sold had access to irrigation (1=yes, 0=no)

WHEAVY - land parcel is irrigated and located in an area where over 50% of the land sold had access to irrigation (1=yes, 0=no)

WATER - farm land has access to irrigation water (1=yes, 0=no)

DIST - distance to nearest market (km)

DISTRD - distance to nearest paved road (km)

OBS #	TPRICE	AREA	BUILD	ASSPRICE	RATIO
1	80000	160	0	27370	2.922908
2	128000	160	48000	26840	4.769001
3	78035	156	0	25510	3.058996
4	90000	151	0	17050	5.278592
5	120000	80	30000	15100	7.94702
6	80000	160	0	28310	2.825857
7	40000	159	0	23500	1.702128
8	300000	160	180000	23340	12.85347
9	120000	159	0	27570	4.352557
10	102550	148	0	25910	3.957931
11	102550	144	0	24650	4.160243
12	63372	156	0	21260	2.980809
13	69547	160	6175	22380	3.107551
14	75511	160	0	24410	3.093445
15	102050	152	0	32840	3.107491
16	61466	158	0	34400	1.786802
17	48000	160	0	26860	1.787044
18	48000	160	0	25030	1.917699
19	56000	160	7000	26620	2.103681
20	56000	160	7000	25490	2.19694
21	80000	159	0	27300	2.930403
22	80000	160	0	26970	2.966259
23	77500	159	0	20070	3.861485
24	130000	160	0	25490	5.100039
25	40000	160	0	18500	2.162162
26	225000	145	60000	25772	8.730405
27	144000	160	0	20870	6.899856
28	144000	159	0	20360	7.072692
29	192000	158	48000	20530	9.352168
30	96600	161	0	28310	3.412222
31	96600	160	0	25360	3.809148
32	62848	145	12000	17580	3.574972
33	112000	160	0	24720	4.530744
34	88176	147	2176	42720	2.064045
35	85998	144	0	32860	2.617103
36	128000	160	0	29260	4.374573
37	36152	161	0	34120	1.059555
38	20160	159	0	25160	0.801272
39	81100	160	0	34460	2.353453
40	121960	160	40860	19260	6.332295
41	62000	160	0	36670	1.690755
42	40500	163	0	37680	1.074841

43	45500	160	0	34100	1.334311
44	90000	159	0	32540	2.765827
45	60000	156	0	27900	2.150538
46	40000	160	0	35800	1.117318
47	48000	160	0	27550	1.742287
48	24000	159	0	16400	1.463415
49	25000	160	0	30700	0.814332
50	80000	159	0	29080	2.751032
51	27000	161	0	20390	1.324179
52	33000	142	0	22430	1.471244
53	80000	159	0	35930	2.226552
54	68000	160	0	29810	2.281114
55	32000	160	0	36040	0.887902
56	84000	160	4000	31000	2.709677
57	56000	159	0	28950	1.93437
58	50000	159	0	33660	1.485443
59	106000	155	0	30780	3.443795
60	106000	152	0	30640	3.45953
61	76800	160	0	28460	2.698524
62	76800	160	0	31900	2.407524
63	55000	159	0	37680	1.45966
64	68344	162	0	38000	1.798526
65	167055	160	0	35670	4.683347
66	84000	160	0	32730	2.566453
67	156959	160	72000	38020	4.128327
68	100750	155	60750	31690	3.179236
69	40000	160	0	37090	1.078458
70	38500	154	0	39330	0.978897
71	38500	154	0	39330	0.978897
72	40000	160	0	34860	1.147447
73	48800	159	0	34910	1.39788
74	64960	163	0	32870	1.97627
75	55000	160	0	22710	2.421841
76	96000	161	0	38130	2.517703
77	32000	160	0	9120	3.508772
78	56000	160	0	40610	1.378971
79	56000	156	0	37500	1.493333
80	96000	160	40000	23790	4.035309
81	160000	156	0	38380	4.168838
82	320000	159	30200	16240	19.70443
83	115000	160	0	12390	9.281679
84	40000	160	0	12740	3.139717
85	40000	160	0	11390	3.511853

86	160000	152	45000	12260	13.05057
87	60000	153	7675	18140	3.307607
88	52325	161	0	13790	3.794416
89	50000	160	0	13010	3.843198
90	244000	160	60000	15380	15.86476
91	56000	160	0	26000	2.153846
92	60000	156	0	13210	4.542014
93	56000	157	0	9470	5.913411
94	96001	157	0	13670	7.022751
95	63335	160	0	13420	4.719449
96	63330	160	0	13060	4.849158
97	63335	160	0	13910	4.553199
98	177900	152	0	16110	11.04283
99	57600	160	0	5470	10.53016
100	44256	148	3741	21750	2.034759
101	47997	157	0	25320	1.895616
102	160000	159	0	29590	5.407232
103	160000	153	0	32650	4.900459
104	40000	159	0	14950	2.675585
105	72000	160	0	18700	3.850267
106	72000	160	0	18520	3.887689
107	128000	160	0	16880	7.582938
108	144000	160	0	19620	7.33945
109	150000	160	0	19870	7.549069
110	64000	160	0	12610	5.075337
111	64000	160	0	10120	6.324111
112	64000	160	0	10750	5.953488
113	64000	160	0	16420	3.897686
114	59625	159	19625	20490	2.909956
115	125000	160	0	63220	1.977222
116	160000	160	0	46280	3.457217
117	160000	160	0	41450	3.860072
118	130000	160	0	38160	3.406709
119	160000	155	30000	37690	4.245158
120	113000	150	0	26040	4.339478
121	104000	160	0	55660	1.868487
122	90000	157	0	28900	3.114187
123	250000	162	0	48670	5.136634
124	160000	158	0	40170	3.983072
125	438975	162	187025	49260	8.911389
126	49600	160	0	26680	1.85907
127	191600	144	51600	48130	3.980885
128	150000	148	10000	42530	3.526922

129	120000	157	0	33090	3.626473
130	255000	158	41800	46780	5.451047
131	207800	158	0	40200	5.169154
132	52000	159	0	42540	1.222379
133	97000	115	0	13090	7.410237
134	64000	158	0	21290	3.006106
135	252735	154	26000	44470	5.68327
136	88000	160	0	36300	2.424242
137	144000	160	0	31800	4.528302
138	80000	160	0	29940	2.672011
139	80000	160	0	24710	3.237556
140	80000	160	0	24420	3.276003
141	155000	152	0	43320	3.578024
142	81000	143	0	30050	2.695507
143	200000	159	45000	50790	3.937783
144	238500	160	24000	30880	7.723446
145	133000	160	26000	41530	3.202504
146	141455	161	0	31770	4.452471
147	176000	155	34545	45530	3.865583
148	230000	154	55000	37550	6.125166
149	175000	160	0	41890	4.177608
150	80000	156	48000	17290	4.626952
151	49600	159	0	36870	1.345267
152	110000	157	0	37510	2.932551
153	32000	150	0	32390	0.987959
154	65000	159	33000	34950	1.8598
155	60000	138	19000	41720	1.438159
156	229700	138	66000	43370	5.296288
157	125000	160	41000	35260	3.545094
158	56000	162	0	36420	1.537617
159	30000	160	0	18720	1.602564
160	212500	158	0	35290	6.021536
161	116800	160	0	51700	2.259188
162	111000	135	22000	40600	2.73399
163	63600	159	0	17720	3.589165
164	63600	157	0	19650	3.236641
165	50000	145	0	16180	3.090235
166	100000	159	0	36920	2.708559
167	95000	157	0	24260	3.915911
168	56000	159	0	37850	1.479524
169	158000	158	40000	71630	2.20578
170	72000	160	0	25510	2.822423
171	72000	160	0	25290	2.846975

172	72000	160	0	27360	2.631579
173	72000	159	0	27530	2.615329
174	109100	156	25000	39490	2.762725
175	144000	153	0	11800	12.20339
176	77000	139	0	25930	2.969533
177	50000	127	0	6680	7.48503
178	100000	137	0	8110	12.33046
179	120000	152	0	25770	4.656577
180	143000	159	23000	29350	4.872232
181	110000	156	14000	11610	9.474591
182	140000	159	30000	24410	5.735354
183	71000	160	0	15740	4.510801
184	96000	160	11000	29610	3.242148
185	200000	160	0	16300	12.26994
186	100000	160	0	34380	2.908668
187	103642	160	0	23600	4.39161
188	48000	154	0	24500	1.959184
189	100000	160	0	14690	6.807352
190	145000	160	0	24970	5.806968
191	100000	160	0	27750	3.603604
192	100000	160	0	33020	3.028468
193	100000	160	0	33650	2.971768
194	100000	160	0	32210	3.104626
195	87550	159	0	35880	2.440078
196	97500	160	0	24310	4.010695
197	122000	158	0	19410	6.28542
198	112000	160	12000	27430	4.083121
199	100000	160	0	33650	2.971768
200	152000	160	0	13390	11.35176
201	150000	160	50000	23490	6.385696
202	107000	154	0	30900	3.462783
203	146000	160	0	30870	4.729511
204	85000	160	0	33472	2.539436
205	125000	153	0	43366	2.882442
206	109500	161	0	43700	2.505721
207	80000	156	0	36648	2.182929
208	50000	158	0	10614	4.710759
209	110000	157	30000	45945	2.394167
210	120000	100	0	25054	4.789654
211	112250	140	12250	31816	3.528099
212	100000	140	0	37007	2.702191
213	95000	156	0	5290	17.95841
214	126000	158	41000	5610	22.45989

215	80000	160	0	5620	14.23488
216	115000	153	35000	5100	22.54902
217	37500	160	0	3650	10.27397
218	70000	161	0	4750	14.73684
219	50000	155	0	4210	11.87648
220	48000	160	0	1400	34.28571
221	51000	165	0	2280	22.36842
222	56000	160	0	2370	23.62869
223	128000	160	72000	2566	49.88309
224	91003	150	35000	2170	41.93687
225	98000	116	0	1230	79.6748
226	20000	168	0	2640	7.575758
227	64000	153	0	2040	31.37255
228	64000	154	0	2190	29.22374
229	64000	152	0	2310	27.70563
230	76725	159	12725	2500	30.69

OBS #	RAIN	DBR	TB	SOILDEPT	WDBR
1	350	1	0	7	0
2	350	1	0	7	0
3	350	1	0	7	1
4	350	1	0	8	0
5	350	1	0	8	0
6	350	1	0	7	0
7	350	1	0	7	0
8	400	0	1	2	0
9	400	0	1	2	0
10	350	1	0	6	1
11	350	1	0	6	1
12	350	1	0	7	0
13	350	1	0	7	0
14	350	1	0	7	0
15	350	0	1	4	0
16	350	1	0	7	0
17	350	1	0	7	0
18	350	1	0	7	0
19	350	0	1	2	0
20	400	0	1	2	0
21	350	1	0	8	0
22	350	1	0	8	0
23	350	1	0	7	0
24	350	1	0	6	0
25	350	1	0	7	0
26	350	1	0	9	0
27	350	1	0	5	0
28	350	1	0	8	0
29	350	1	0	9	0
30	350	1	0	9	0
31	350	1	0	9	0
32	350	1	0	7	0
33	350	1	0	7	0
34	400	0	1	3	0
35	400	0	1	4	0
36	400	0	1	2	0
37	350	1	0	6	0
38	350	1	0	6	0
39	350	1	0	7	0
40	350	1	0	7	0
41	400	0	1	5	0
42	400	0	1	5	0

43	400	0	1	5	0
44	350	1	0	7	0
45	300	0	0	4	0
46	350	1	0	6	0
47	350	1	0	7	0
48	350	1	0	7	0
49	300	0	0	4	0
50	350	1	0	4	0
51	350	1	0	7	0
52	350	1	0	7	0
53	400	0	1	5	0
54	400	0	1	4	0
55	400	0	1	5	0
56	400	0	1	5	0
57	350	1	0	6	0
58	350	1	0	6	0
59	300	0	0	5	0
60	300	0	0	5	0
61	400	0	1	5	0
62	400	0	1	5	0
63	350	1	0	9	1
64	400	0	1	5	0
65	350	1	0	8	1
66	400	0	1	5	0
67	400	0	1	4	0
68	350	1	0	7	0
69	350	1	0	7	0
70	350	1	0	9	1
71	350	1	0	9	1
72	350	1	0	7	0
73	350	1	0	9	1
74	400	0	1	5	0
75	350	1	0	5	0
76	350	1	0	6	0
77	350	1	0	7	0
78	350	1	0	8	1
79	350	1	0	8	1
80	350	1	0	7	0
81	350	1	0	9	1
82	350	1	0	9	1
83	300	0	0	4	0
84	300	0	0	4	0
85	300	0	0	4	0

86	350	1	0	3	0
87	300	0	0	5	0
88	300	0	0	4	0
89	300	0	0	5	0
90	300	0	0	4	0
91	300	1	0	7	0
92	300	0	0	4	0
93	300	0	0	4	0
94	300	0	0	4	0
95	300	0	0	4	0
96	300	0	0	4	0
97	300	0	0	4	0
98	300	1	0	3	0
99	300	0	0	4	0
100	350	1	0	4	0
101	350	1	0	4	0
102	350	1	0	7	1
103	350	1	0	7	1
104	300	0	0	4	0
105	300	0	0	5	0
106	300	0	0	5	0
107	300	0	0	5	0
108	300	0	0	5	0
109	300	0	0	5	0
110	350	1	0	3	0
111	350	1	0	3	0
112	350	1	0	3	0
113	350	1	0	3	0
114	300	0	0	5	0
115	350	1	0	7	1
116	350	1	0	7	1
117	350	1	0	7	1
118	350	1	0	7	1
119	350	1	0	7	1
120	350	1	0	7	1
121	350	1	0	5	0
122	350	1	0	7	1
123	350	1	0	7	1
124	350	1	0	7	1
125	350	1	0	7	1
126	350	1	0	7	0
127	350	1	0	7	1
128	350	1	0	7	1

129	350	1	0	7	1
130	350	1	0	7	1
131	350	1	0	7	1
132	350	1	0	7	1
133	350	1	0	7	0
134	350	1	0	7	0
135	350	1	0	7	1
136	350	1	0	7	0
137	350	1	0	7	0
138	350	1	0	6	0
139	350	1	0	5	0
140	350	1	0	5	0
141	350	1	0	7	1
142	350	1	0	7	1
143	350	1	0	7	1
144	350	1	0	7	1
145	350	1	0	7	1
146	350	1	0	7	1
147	350	1	0	7	1
148	350	1	0	7	1
149	350	1	0	7	1
150	300	0	0	5	0
151	300	0	0	5	0
152	300	0	0	5	0
153	300	0	0	5	0
154	300	0	0	5	0
155	300	0	0	5	0
156	300	0	0	5	0
157	300	0	0	5	0
158	300	0	0	5	0
159	300	1	0	3	0
160	300	0	0	5	0
161	300	0	0	5	0
162	350	1	0	4	1
163	300	0	0	5	0
164	300	0	0	5	0
165	300	0	0	5	0
166	300	0	0	5	0
167	300	0	0	5	0
168	300	0	0	5	0
169	300	0	0	5	0
170	350	1	0	3	0
171	350	1	0	3	0

172	350	1	0	3	0
173	350	1	0	3	0
174	300	0	0	5	0
175	300	0	0	5	0
176	300	0	0	3	0
177	300	0	0	3	0
178	300	0	0	4	0
179	300	0	0	4	0
180	300	0	0	3	0
181	300	0	0	4	0
182	300	0	0	3	0
183	300	0	0	3	0
184	300	0	0	3	0
185	300	0	0	3	0
186	300	0	0	4	0
187	300	0	0	4	0
188	300	0	0	4	0
189	300	0	0	4	0
190	300	0	0	4	0
191	300	0	0	4	0
192	300	0	0	4	0
193	300	0	0	4	0
194	300	0	0	5	0
195	300	0	0	4	0
196	300	0	0	4	0
197	300	0	0	4	0
198	300	0	0	4	0
199	300	0	0	4	0
200	300	0	0	4	0
201	300	0	0	4	0
202	300	0	0	4	0
203	300	0	0	4	0
204	300	0	0	5	0
205	300	0	0	5	0
206	300	0	0	5	0
207	300	0	0	5	0
208	300	1	0	7	0
209	300	0	0	5	0
210	300	0	0	5	0
211	300	0	0	4	0
212	300	0	0	5	0
213	300	0	0	5	0
214	300	0	0	5	0

215	300	0	0	5	0
216	300	0	0	5	0
217	300	0	0	5	0
218	300	0	0	5	0
219	300	0	0	4	0
220	300	0	0	5	0
221	300	0	0	5	0
222	300	0	0	5	0
223	300	0	0	5	0
224	300	0	0	5	0
225	300	0	0	5	0
226	300	0	0	5	0
227	300	0	0	5	0
228	300	0	0	5	0
229	300	0	0	5	0
230	300	0	0	5	0

OBS #	VLC	LC	MC	LT	AT
1	1	0	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0
4	1	0	0	0	0
5	1	0	0	0	0
6	1	0	0	0	0
7	1	0	0	0	0
8	1	0	0	0	0
9	1	0	0	0	0
10	1	0	0	0	0
11	1	0	0	0	0
12	1	0	0	0	0
13	1	0	0	0	0
14	1	0	0	0	0
15	1	0	0	0	0
16	1	0	0	0	0
17	1	0	0	0	0
18	1	0	0	0	0
19	1	0	0	0	0
20	1	0	0	0	0
21	1	0	0	0	0
22	1	0	0	0	0
23	1	0	0	0	0
24	1	0	0	0	0
25	1	0	0	0	0
26	1	0	0	0	0
27	1	0	0	0	0
28	1	0	0	0	0
29	1	0	0	0	0
30	1	0	0	0	0
31	1	0	0	0	0
32	1	0	0	0	0
33	1	0	0	0	0
34	1	0	0	0	0
35	1	0	0	0	0
36	1	0	0	0	0
37	0	0	0	0	1
38	0	0	0	0	1
39	0	0	0	0	1
40	0	0	0	0	1
41	0	0	0	0	1
42	0	0	0	0	1

43	0	0	0	0	1
44	0	0	0	0	1
45	0	0	0	0	1
46	0	0	0	0	1
47	0	0	0	0	1
48	0	0	0	0	1
49	0	0	0	0	1
50	0	0	0	0	1
51	0	0	0	0	1
52	0	0	0	0	1
53	0	0	0	0	1
54	0	0	0	0	1
55	0	0	0	0	1
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64	0	0	0	0	1
65	0	0	0	0	1
66	0	0	0	0	1
67	0	0	0	0	1
68	0	0	0	0	1
69	0	0	0	0	1
70	0	0	0	0	1
71	0	0	0	0	1
72	0	0	0	0	1
73	0	0	0	0	1
74	0	0	0	0	1
75	0	0	0	0	1
76	0	0	0	0	1
77	0	0	0	0	1
78	0	0	0	0	1
79	0	0	0	0	1
80	0	0	0	0	1
81	0	0	0	0	1
82	0	0	0	0	1
83	0	0	0	0	1
84	0	0	0	0	1
85	0	0	0	0	1

86	0	0	0	0	1
87	0	0	0	0	1
88	0	0	0	0	1
89	0	0	0	0	1
90	0	0	0	0	1
91	0	0	0	0	1
92	0	0	0	0	1
93	0	0	0	0	1
94	0	0	0	0	1
95	0	0	0	0	1
96	0	0	0	0	1
97	0	0	0	0	1
98	0	0	0	0	1
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100	0	0	0	0	1
101	0	0	0	0	1
102	0	0	0	0	1
103	0	0	0	0	1
104	0	0	0	0	1
105	0	0	0	0	1
106	0	0	0	0	1
107	0	0	0	0	1
108	0	0	0	0	1
109	0	0	0	0	1
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111	0	0	0	0	1
112	0	0	0	0	1
113	0	0	0	0	1
114	0	0	0	0	1
115	0	1	0	0	0
116	0	1	0	0	0
117	0	1	0	0	0
118	0	1	0	0	0
119	0	1	0	0	0
120	0	1	0	0	0
121	0	1	0	0	0
122	0	1	0	0	0
123	0	1	0	0	0
124	0	1	0	0	0
125	0	1	0	0	0
126	0	1	0	0	0
127	0	1	0	0	0
128	0	1	0	0	0

129	0	1	0	0	0
130	0	1	0	0	0
131	0	1	0	0	0
132	0	1	0	0	0
133	0	1	0	0	0
134	0	1	0	0	0
135	0	1	0	0	0
136	0	1	0	0	0
137	0	1	0	0	0
138	0	1	0	0	0
139	0	1	0	0	0
140	0	1	0	0	0
141	0	1	0	0	0
142	0	1	0	0	0
143	0	1	0	0	0
144	0	1	0	0	0
145	0	1	0	0	0
146	0	1	0	0	0
147	0	1	0	0	0
148	0	1	0	0	0
149	0	1	0	0	0
150	0	0	0	1	0
151	0	0	0	0	0
152	0	0	0	1	0
153	0	0	0	0	0
154	0	0	0	0	0
155	0	1	0	0	0
156	0	1	0	0	0
157	0	1	0	0	0
158	0	0	0	0	0
159	0	0	0	0	0
160	0	1	0	0	0
161	0	1	0	0	0
162	0	1	0	0	0
163	0	0	0	1	0
164	0	0	0	1	0
165	0	0	0	1	0
166	0	0	0	1	0
167	0	0	0	1	0
168	0	0	0	0	0
169	0	1	0	0	0
170	0	1	0	0	0
171	0	1	0	0	0

172	0	1	0	0	0
173	0	1	0	0	0
174	0	1	0	0	0
175	0	0	0	0	0
176	0	0	0	1	0
177	0	0	0	1	0
178	0	0	0	1	0
179	0	0	0	1	0
180	0	0	0	1	0
181	0	0	0	1	0
182	0	0	0	1	0
183	0	0	0	1	0
184	0	0	0	1	0
185	0	0	0	1	0
186	0	0	0	1	0
187	0	0	0	1	0
188	0	0	0	1	0
189	0	0	0	1	0
190	0	0	0	1	0
191	0	0	0	1	0
192	0	0	0	1	0
193	0	0	0	1	0
194	0	0	0	1	0
195	0	0	0	1	0
196	0	0	0	0	0
197	0	0	0	0	0
198	0	0	0	1	0
199	0	0	0	1	0
200	0	0	0	0	0
201	0	0	0	1	0
202	0	0	0	1	0
203	0	0	0	1	0
204	0	0	1	0	0
205	0	0	1	0	0
206	0	0	1	0	0
207	0	0	1	0	0
208	0	0	1	0	0
209	0	0	1	0	0
210	0	0	1	0	0
211	0	0	1	0	0
212	0	0	1	0	0
213	0	0	0	0	1
214	0	0	0	0	1

215	0	0	0	0	1
216	0	0	0	0	1
217	0	0	0	0	1
218	0	0	0	0	1
219	0	0	0	0	1
220	0	0	0	0	1
221	0	0	0	0	1
222	0	0	0	0	1
223	0	0	0	0	1
224	0	0	0	0	1
225	0	0	0	0	1
226	0	0	0	0	0
227	0	0	0	0	0
228	0	0	0	0	0
229	0	0	0	0	0
230	0	0	0	0	0

OBS #	HEAVY	WHEAVY	WATER	DIST	DISTRD
1	0	0	0	90	2
2	0	0	0	62	5
3	0	0	1	80	7
4	0	0	0	49	0
5	0	0	0	47	0
6	0	0	0	70	0
7	0	0	0	69	1
8	0	0	0	32	2
9	0	0	0	36	11
10	0	0	1	70	0
11	0	0	1	70	0
12	0	0	0	100	0
13	0	0	0	100	0
14	0	0	0	79	16
15	0	0	0	30	1
16	0	0	0	78	0
17	0	0	0	65	11
18	0	0	0	69	11
19	0	0	0	33	10
20	0	0	0	33	10
21	0	0	0	79	0
22	0	0	0	79	0
23	0	0	0	90	0
24	0	0	0	79	2
25	0	0	0	55	10
26	0	0	0	48	0
27	0	0	0	105	9
28	0	0	0	90	5
29	0	0	0	90	0
30	0	0	0	100	20
31	0	0	0	110	21
32	0	0	0	80	2
33	0	0	0	62	2
34	0	0	0	28	0
35	0	0	0	28	0
36	0	0	0	38	7
37	0	0	0	45	9
38	0	0	0	43	7
39	0	0	0	21	16
40	0	0	0	22	14
41	0	0	0	29	1
42	0	0	0	32	0

43	0	0	0	37	5
44	0	0	0	45	10
45	0	0	0	26	5
46	0	0	0	30	4
47	0	0	0	23	1
48	0	0	0	45	10
49	0	0	1	68	18
50	0	0	0	41	5
51	0	0	0	14	1
52	0	0	0	10	0
53	0	0	0	31	10
54	0	0	0	41	8
55	0	0	0	29	2
56	0	0	0	37	2
57	0	0	0	29	16
58	0	0	0	22	0
59	0	0	1	60	8
60	0	0	1	60	8
61	0	0	0	36	8
62	0	0	0	36	6
63	0	0	1	25	0
64	0	0	0	22	0
65	0	0	1	46	14
66	0	0	1	46	14
67	0	0	0	48	14
68	0	0	0	31	10
69	0	0	0	31	10
70	0	0	1	31	10
71	0	0	1	30	9
72	0	0	0	20	5
73	0	0	1	6	1
74	0	0	0	29	0
75	0	0	0	38	2
76	0	0	0	27	5
77	0	0	0	25	8
78	0	0	1	19	2
79	0	0	1	19	1
80	0	0	0	11	1
81	0	0	1	15	4
82	0	0	1	30	20
83	0	0	0	45	15
84	0	0	0	39	9
85	0	0	0	36	4

86	0	0	0	25	1
87	0	0	0	48	0
88	0	0	0	21	19
89	0	0	0	50	0
90	0	0	0	30	11
91	0	0	0	5	3
92	0	0	0	36	5
93	0	0	0	42	12
94	0	0	0	14	0
95	0	0	0	47	5
96	0	0	0	47	5
97	0	0	0	48	16
98	0	0	0	50	1
99	0	0	0	58	0
100	0	0	0	26	0
101	0	0	0	25	0
102	0	0	1	7	0
103	0	0	1	8	0
104	0	0	0	31	1
105	0	0	0	34	2
106	0	0	0	34	2
107	0	0	0	33	1
108	0	0	0	33	1
109	0	0	0	38	3
110	0	0	0	20	9
111	0	0	0	19	7
112	0	0	0	22	10
113	0	0	0	19	8
114	0	0	0	36	22
115	1	1	1	30	5
116	1	1	1	33	11
117	1	1	1	33	11
118	1	1	1	38	11
119	1	1	1	38	11
120	1	1	1	32	12
121	1	0	0	6	4
122	1	1	1	22	2
123	1	1	1	20	5
124	1	1	1	33	5
125	1	1	1	20	0
126	1	0	0	32	10
127	1	1	1	5	0
128	1	1	1	10	2

129	1	1	1	31	11
130	1	1	1	9	0
131	1	1	1	25	2
132	1	1	1	38	3
133	1	0	0	40	5
134	1	0	0	20	0
135	1	1	1	16	10
136	1	0	0	28	4
137	1	0	0	30	20
138	1	0	0	30	20
139	1	0	0	30	20
140	1	0	0	30	20
141	1	1	1	20	4
142	1	1	1	16	4
143	1	1	1	14	6
144	1	1	1	4	0
145	1	1	1	7	1
146	1	1	1	28	2
147	1	1	1	21	0
148	1	1	1	22	2
149	1	1	1	28	4
150	1	0	0	47	19
151	1	1	1	25	1
152	1	1	1	15	2
153	1	1	1	15	8
154	1	1	1	22	3
155	1	1	1	32	0
156	1	1	1	35	5
157	1	1	1	58	1
158	1	1	1	25	10
159	1	0	0	25	1
160	1	1	1	48	1
161	1	1	1	42	1
162	1	1	1	30	2
163	1	0	0	35	15
164	1	0	0	35	16
165	1	1	1	20	1
166	1	1	1	14	1
167	1	1	1	12	0
168	1	1	1	10	2
169	1	1	1	38	1
170	1	0	0	32	1
171	1	0	0	32	1

172	1	0	0	32	2
173	1	0	0	32	2
174	1	1	1	34	1
175	1	0	0	11	1
176	1	1	1	41	8
177	1	1	1	30	14
178	1	1	1	26	8
179	1	1	1	25	9
180	1	1	1	33	0
181	1	1	1	38	1
182	1	1	1	34	0
183	1	1	1	20	1
184	1	1	1	35	2
185	1	1	1	21	0
186	1	1	1	49	5
187	1	1	1	29	2
188	1	1	1	36	14
189	1	1	1	35	10
190	1	1	1	14	0
191	1	1	1	11	0
192	1	1	1	29	0
193	1	1	1	28	0
194	1	1	1	26	0
195	1	1	1	45	0
196	1	1	1	30	0
197	1	1	1	30	1
198	1	1	1	45	5
199	1	1	1	26	0
200	1	1	1	41	3
201	1	1	1	50	3
202	1	1	1	29	8
203	1	1	1	20	9
204	1	1	1	20	2
205	1	1	1	17	0
206	1	1	1	25	6
207	1	1	1	20	6
208	1	0	0	70	28
209	1	1	1	26	8
210	1	1	1	9	0
211	1	1	1	12	5
212	0	1	1	20	0
213	0	0	1	21	3
214	0	0	1	15	0

215	0	0	1	21	3
216	0	0	1	22	3
217	0	0	1	15	0
218	0	0	1	12	0
219	0	0	1	10	5
220	0	0	0	24	4
221	0	0	0	21	0
222	0	0	0	18	0
223	0	0	0	18	0
224	0	0	0	10	0
225	0	0	0	10	2
226	0	0	0	28	0
227	0	0	0	19	0
228	0	0	0	19	0
229	0	0	0	18	0
230	0	0	0	6	0

OBS #	PRICE	PASTURE	WTB	STONES	HOUSE
1	500	0	0	0	0
2	800	0	0	0	0
3	500	12	0	0	0
4	598	5	0	0	0
5	1500	0	0	0	0
6	500	0	0	0	0
7	251	21	0	0	0
8	1875	9	0	1	1
9	757	2	0	1	0
10	692	16	0	0	0
11	710	1	0	0	0
12	405	2	0	0	0
13	434	3	0	0	1
14	471	0	0	0	0
15	670	5	0	1	1
16	389	0	0	0	0
17	300	52	0	0	0
18	300	6	0	0	0
19	350	12	0	1	0
20	350	7	0	1	0
21	503	0	0	0	0
22	500	0	0	0	0
23	486	9	0	0	0
24	812	0	0	0	0
25	250	25	0	1	0
26	1554	60	0	0	1
27	900	15	0	0	0
28	905	2	0	1	0
29	1212	51	0	0	1
30	599	15	0	0	0
31	900	13	0	0	0
32	431	19	0	0	1
33	700	0	0	0	0
34	600	6	0	1	1
35	598	5	0	1	0
36	800	1	0	1	1
37	225	0	0	0	0
38	127	0	0	0	0
39	506	0	0	0	0
40	762	28	0	0	1
41	387	1	0	0	0
42	249	3	0	0	1

43	284	10	0	0	0
44	566	5	0	0	0
45	385	2	0	0	0
46	250	0	0	0	0
47	300	22	0	0	0
48	151	58	0	0	0
49	156	3	0	0	0
50	503	0	0	1	0
51	168	32	0	0	1
52	233	9	0	0	0
53	503	10	0	0	0
54	425	20	0	1	0
55	200	4	0	0	0
56	525	16	0	0	1
57	352	8	0	0	0
58	314	0	0	0	0
59	683	4	0	0	0
60	698	5	0	0	0
61	480	3	0	1	1
62	480	4	0	1	0
63	345	6	0	0	0
64	424	4	0	0	0
65	1044	0	0	0	0
66	525	13	1	0	0
67	980	3	0	0	0
68	649	13	0	0	1
69	250	0	0	0	0
70	250	0	0	0	0
71	250	0	0	0	0
72	250	0	0	0	0
73	306	0	0	0	0
74	399	7	0	0	0
75	343	4	0	0	0
76	595	0	0	0	0
77	200	78	0	0	0
78	350	0	0	0	0
79	358	0	0	0	0
80	600	18	0	1	1
81	1025	0	0	0	0
82	2009	99	0	1	1
83	718	8	0	1	0
84	250	0	0	1	0
85	250	25	0	1	0

86	1052	9	0	1	1
87	391	10	0	1	1
88	324	5	0	1	0
89	300	20	0	1	0
90	1525	0	0	0	0
91	350	20	0	1	0
92	384	0	0	0	1
93	353	42	0	1	0
94	611	12	0	1	0
95	395	2	0	1	0
96	396	0	0	1	0
97	395	6	0	1	0
98	1174	24	0	1	0
99	360	158	0	1	0
100	300	12	0	1	1
101	305	0	0	1	0
102	1005	1	0	0	0
103	1043	0	0	0	0
104	251	6	0	0	1
105	1350	0	0	0	0
106	450	0	0	1	0
107	800	0	0	1	0
108	900	0	0	0	0
109	937	0	0	0	0
110	400	12	0	0	0
111	400	76	0	1	0
112	400	80	0	1	0
113	400	7	0	1	0
114	374	0	0	0	1
115	781	0	0	0	1
116	1003	0	0	0	1
117	1000	0	0	0	0
118	812	0	0	0	0
119	1034	5	0	0	1
120	751	5	0	1	0
121	650	0	0	0	1
122	574	0	0	0	0
123	1544	0	0	0	0
124	1012	0	0	0	0
125	2702	13	0	0	1
126	310	1	0	1	0
127	1331	0	0	0	1
128	1011	0	0	0	0

129	766	23	0	0	1
130	1618	0	0	0	1
131	1312	0	0	0	0
132	327	4	0	0	1
133	847	44	0	0	0
134	405	12	0	0	0
135	1636	0	0	0	1
136	550	0	0	0	0
137	900	0	0	0	0
138	500	0	0	0	0
139	500	5	0	1	0
140	500	7	0	1	0
141	1022	0	0	0	0
142	567	5	0	0	0
143	1257	4	0	0	0
144	1490	60	0	0	1
145	831	10	0	0	1
146	877	19	0	0	1
147	1135	13	0	0	1
148	1495	17	0	0	1
149	1093	0	0	0	0
150	1550	3	0	1	1
151	311	1	0	0	0
152	700	9	0	0	0
153	214	3	0	0	0
154	408	23	0	0	1
155	436	3	0	0	1
156	1659	8	0	0	1
157	781	30	0	0	1
158	345	9	0	0	0
159	187	0	0	1	0
160	1344	23	0	0	0
161	730	6	0	0	0
162	821	0	0	0	1
163	400	4	0	1	0
164	405	2	0	0	0
165	344	48	0	0	0
166	628	2	0	0	0
167	605	3	0	0	0
168	352	10	0	0	0
169	1000	4	0	0	1
170	450	0	0	0	0
171	450	0	0	0	0

172	450	0	0	0	0
173	454	0	0	0	0
174	700	4	0	0	1
175	941	0	0	0	0
176	553	2	0	0	0
177	395	94	0	0	0
178	730	22	0	0	0
179	789	18	0	0	0
180	899	6	0	0	1
181	706	49	0	0	0
182	880	46	0	0	1
183	443	60	0	0	0
184	600	12	0	0	1
185	1251	56	0	0	1
186	627	3	0	0	1
187	647	10	0	0	0
188	312	24	0	1	0
189	625	43	0	0	1
190	906	15	0	0	1
191	625	23	0	0	0
192	625	14	0	0	0
193	625	18	0	0	1
194	626	16	0	0	0
195	552	2	0	0	1
196	609	40	0	1	1
197	774	50	0	1	0
198	700	20	0	0	1
199	625	18	0	0	1
200	950	29	0	0	0
201	937	15	0	0	1
202	694	10	0	0	1
203	912	2	0	0	0
204	530	25	0	1	1
205	1048	8	0	1	0
206	681	13	0	1	0
207	512	26	0	1	0
208	316	83	0	1	0
209	700	2	0	1	1
210	1150	56	0	1	0
211	702	20	0	1	1
212	634	17	0	1	0
213	609	0	0	0	0
214	798	2	0	0	1

215	500	3	0	0	0
216	752	7	0	0	1
217	234	56	0	0	0
218	436	2	0	0	1
219	323	0	0	0	1
220	300	44	0	1	0
221	300	5	0	1	0
222	350	0	0	0	0
223	800	0	0	0	1
224	608	3	0	0	1
225	848	23	0	0	0
226	119	0	0	1	0
227	417	0	0	0	0
228	416	0	0	0	0
229	420	0	0	0	0
230	482	0	0	0	1

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